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R SENSES AND WHAT
THEY MEAN TO US

THE SENSE OF SIGHT

FRANK N · SPINDLER

THE SENSE OF SIGHT

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Our Senses Series—George Van N. Dearborn, Editor

THE SENSE OF SIGHT

BY

FRANK NICHOLAS SPINDLER

Vice-President and Professor of Psychology and Education,
State Normal School, Stevens Point, Wisconsin

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TO

HENRY CHURCHILL KING

(PRESIDENT OF OBERLIN COLLEGE)

MY FIRST MASTER IN PHILOSOPHY AND
PSYCHOLOGY, THIS BOOK IS
GRATEFULLY DEDICATED

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PREFACE

The aim of this book is to tell the story of the wonderful power of Vision in plain English and in a readable way, and yet keep true to the scientific facts and theories.

The writer feels that such a book will interest every intelligent person and hopes that the reading of it will increase the appreciation and interest of every reader in this most knowledge giving sense.

The writer has been more interested of late years in Vision than in any other sense, as his mind was forcibly directed to this sense, by the loss through an accident, fourteen years ago, of his left eye. This near call to blindness led to a deep interest and appreciation of the sense of Sight.

The author owes much to the teaching and works of his former instructors in Harvard University, James, Munsterburg, Delabarre and Lough, and to the works of many other Psycho-

logists and Physiologists too numerous to expressly mention.

To the following members of the faculty of the State Normal School, Stevens Point, Wisconsin, he wishes also to extend his thanks: to Professor Raymond W. Fairchild, Head of the Department of Biology for his careful reading of Chapter Two, and his helpful criticisms and suggestions; to Professor Alfred J. Herrick, Head of the Department of Physics, for his invaluable criticisms and help on Chapter Three; to Miss Eleanor C. Flanagan, Head of the Art Department, for the preparation of the Drawings; to Miss Mary Jones of the Department of Biology for the drawings of the eye. Finally the author would express his thanks to his wife for her help in preparing the manuscript.

FRANK NICHOLAS SPINDLER.

Stevens Point, Wisconsin.

March, 1917

EDITORIAL INTRODUCTION

Few people, comparatively, however intelligent and generally thoughtful, have as yet stopped to consider the surpassing interest and the unique importance of Our Senses. Living gateways as the sense organs are between ourselves and our ever-changing surroundings, both spiritual and material, they constitute the channels not only of our *life-satisfaction,* but of all our immediate *knowledge* as well. If, then, in discussing them, biological imagination and breadth and depth go hand in hand with technical knowledge of the highest grade, the volumes comprised should be both human and scientific. And these volumes are so, and will be. It is because of such possibilities that a series like the present, authentic yet interesting and inexpensive, must appeal to the intelligent man or woman of to-day. As contributions to psychology and to education their value is certain to be great, as indeed is indicated by the list of their authors, whom it would be superfluous to praise or even to portray.

Small in number are the topics in all the wondrous range of the science of living things that are more alluring for their very mystery and romance than these same gateways by which we may go out into " our world " and by which this same great world may come into us and, for the little span of life, lend us a feeling of home-dwelling.

Within the past decade there has been a general popular awakening from the former uninterested attitude toward these phenomena of the physical and mental processes by which we keep in touch with the things outside ourselves. A fair knowledge of the rudiments of biology, of physiology, and of psychology now has become part of the curriculum of our schools and colleges. And of these three sciences it is psychology which has entered so deeply into our everyday life — business life as well as personal — that at last no one can escape its influence. And no one wishes to, for psychology in a sense has become the intellectual handmaiden of all who think in terms of to-day, with to-day's amazing development of insight into the mortal meanings of our very selves, body always as well as soul. Our scientific realization of our true continuity with all things else goes on apace, and our personal relations to the bound-

less, perhaps Infinite, Cosmos of consciousness, life, and energy seem ever clearer. Thus, in a way, the sense organs give us personal anchorage in a Sea which else sometimes, from its very immensity and stress, would overwhelm us. Our range, although the broadest as yet vouchsafed to life, is as it were but a mere line out into the complexity of the Actual. The first step to the appreciation of this complexity and its implications for the human mind is knowledge of the conditions of its acquirement,— of the sense organs and of the perplexing brain behind them.

Editorial duty or privilege fails to know much as yet of the detailed contents of these several volumes. But the editor does know not a little about the arrangers and expounders of the volumes' contents, and he knows that they are women and men of conspicuous sense — trustworthy in every sense. The books are the best of their kind and are in a class by themselves. They are the standard authority for ordinary use. These volumes when disposed as a red-backed set on one's library shelf will be a set of books to be proud of. And the high school boys and girls and their fathers evenings and on Sundays and their mothers at the club all alike will think of them as highly valued friends, both wise and agreeable, as

pleasant to meet for an hour as the most welcome visitor well could be. No higher "authority" exists than that which these authors represent; and it would be hard to find those who could set forth "authority" more gracefully. Each knows that literary *enjoyment* usually goes hand in hand with that *wisdom* which extended is the director of Life itself.

For eighteen years the author of this monograph on Seeing has succeeded in raising his psychology out of the purely and narrowly academic level into a school-subject close to Life. In fact, ever since Professor Spindler left his studies in the Harvard Philosophic Department when "in its glory," he has made psychology real and human to many students in colleges in Nebraska, Kansas, Michigan, and now in Wisconsin, where long since he found himself at home. This career gives those who understand its import the quick key to his masterful psychology: —

It is practicable in every page. In Chapters IV and IX, for example, "How to Learn to Know the Outer World Through Vision," and "The Development and Training of Vision in the Child," one has a glimpse of applied educational psychology at its best. It is to be hoped that this

skill in giving useful psychology to a psychology-hungry practical world will be very much practiced! From the constructive point of view, then, this book on the sense of sight is undoubtedly excellent; as well as interesting.

As to the subject about which it is written, and Professor Spindler's selection from its wealth of lore, scientific and humanistic, it is less easy to say a few words worth the reading.

Many readers of this book will be glad to have explained to them clearly, as it is herein, something as to color-blindness; why some folks insist that "green" objects are "red." Evidently it's a matter of majority-rule, after all!

Vision constitutes a large and dominant part, seemingly at least, of usual human experience from moment to moment whenever our eyes are open. Its indescribable mental contributions of colors innumerable and forms almost always unique, make up, for the great unlearned majority of "just folks" the larger substance, so to say, of consciousness. We go so far oftentimes as to think we "wish to see a man," when in reality to see him is the least important part of our intended interview with him; and it is no uncommon thing now-a-days to hear a person say, under or over miles of tall buildings and through a slender cop-

per wire, "I haven't seen you before for a long time," etc. And sometimes we "see" the point of a story, even though it have none. So much has vision become a metonomy for almost every form of mental action!

The wholly unaccountable nature of our consciousness of *light* and of *color,* basal mysteries probably forevermore in the qualities of mind, gives vision an authority as well as an uniqueness which if we use the trite phrase once more bids us call it the queen of the senses. "Light,"— what can it be? what is it? what lies beneath its essential, flooding luminosity, its inherent light-ness? Surely not even the idealistic metaphysician knows, — though of all men he perhaps most nearly understands, for he claims it as a phase of *Mind* itself.

But as elsewhere (in a modest treatise in this Series on the inherent movement-sensations) I have tried to show more conclusively, a little thought shows that sound is just as wonderful as light, and tastes and pains and odors and the joint-sensations of the movements of our legs and arms, as wonderful as either. Sensation is "all-of-a-piece," though it be never and nowhere twice alike. With motion, it underlies in a sense our very selves.

Light and color, then, above all things else (save music-sounds to certain numerous souls) give us delight, a sense of freedom, of intensive existence, of inexpressible but substantial Joy-of-Reality on this vast speck of warring matter floating we know not whither into Space.

Some of the purchasers of this volume will be glad to learn how it is that we can see in the "dark." And why some folks can't do so.

And we shudder and we cringe and we begin to die, almost (like the hundreds of the *Titanic* and the *Lusitania*), as we think of the utter blackness of the vast and unseen depths of the sea even a few hundred fathoms down; or of the reaches of space outside the film of our Earth's atmosphere; or of the closely-wrapping bosom of our world's huge burial-ground. And these dark thoughts quickly bring us to a most useful conclusion: Sensation is part of ourselves, our mental selves, of our minds, our consciousness. And no one aspect of it, be it heat or odor or color or pleasure or a sense of movement or of weight, is more predominant, more nearly "queen," than is any other.

It is better for human happiness (although not for vocational efficiency, as yet) to be blind than to be wholly deaf, especially be the afflictions com-

pared total and from birth. Vision gives us our grosser relationships in space ("orients" us, is the proper word), shows us where and when to start our bodily actions, and when and where to stop them, in a rough kind of way. But we could never possibly learn to live our human life of numberless voluntary efforts and fine motor adjustment by vision's guidance alone; the development of deliberate movement in the first two years of life directed by sight alone, is quite unthinkable, for sight is an extrinsic sense.

Thus may one detract from the "queenliness," the quasi-dominance, of the visual sense without fear of materially lessening its all-surpassing interest for the multitude of women and of thoughtful men. Professor Spindler has set forth well all these things and many more besides, even in this inexpensive book. Perusal will show, too, that he has done it well. Thousands will find within its covers just what they long have wished to have expressed to them thus simply and with this "authority."

G. V. N. D.

Cambridge, Massachusetts,
May, 1917.

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THE SENSE OF SIGHT

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CHAPTER I

THE VALUE AND IMPORTANCE OF SIGHT

At the head of all the human senses stands the glorious sense of sight, aptly called the " Queen " of our senses.

It may be admitted that touch is the basis and foundation of all the senses, that it is the " King " in this sensory realm, to which all final decisions regarding the reality and existence of objects are referred, but how narrow, limited, and prosaic is its world when divorced from the sight! The world of touch is the world of the lowest animals, the original primeval world of simple reflex actions and circumscribed life. The world of the blind man is a world as big as his arms can reach, a more or less of a piece-meal world. The world which opens to the seeing mind, on the other hand, is a unified, infinitely extended, beautifully colored and variegated world. The eye extends its sensory power to the remote star, and also can be-

come aware of the minute speck of dust not perceptible to the basic touch.

The eye is the last and finest effort of nature in the evolution of the sense organs, and vision, with all who see, largely usurps the work of reporting the outer world to the mind. Very few of us would be willing to eat in the dark; we would not feel safe to rely on touch, taste, or smell; we practically neglect these senses and rely for our safety upon sight. Our first impulse when a noise is heard or some strange object is felt in the dark is to strike a light. Vision is a knowledge giving sense to an unequalled degree, but it is also a superb protective sense.

Touch can only warn us of danger when the object is already against us, smell only gives us warning from a short distance away, the warning of taste may come too late to prevent us from swallowing a poison, sound waves travel only a limited distance with comparative slowness and give us little idea of direction; while sight gives warning even when the danger is far away, and gives an accurate idea of direction and thus we can prepare to meet the emergency. It is impossible to explain to the congenitally blind how it can be known that a person is coming up the path long before the footsteps can be heard, or how one can

go straight across the field at night guided only by the distant light in the window.

The ear is the organ of time succession and rhythm, while the eye is the organ of all others of space perception.

In space we live and move and have our being. We find in the higher vertebrate animals, and most especially in man, the greatest mobility and widest range of action and adaptation to environment, the greatest intelligence and growth of mental power; due to the possession of self-adjusting and highly perfected eyes.

Not only is sight a wonderful knowledge giving and protective sense but it is also the greatest sense from the æsthetic and emotional standpoint. In this regard it is approached only by hearing. Who is not filled with joy when he looks upon the natural world, when he sees the blue of the summer sky traced with fleecy clouds, the green lush grass, the myriads of many colored flowers, the crimson and gold of the setting sun, the silvery light of the moon, the purple haze of the distant mountain? Who does not feel an inner glow when he sees the happy face of a child or the charming countenance of a beautiful woman, or who is not filled with admiration when he runs his eye over the graceful shapes of the animals or looks upon the variegated

plumage of the birds? The wonderful harmony of color, line and form found in painting, sculpture, and architecture are only intelligible through the seeing eye. To the blind man the inspiring and enduring paintings of a Michael Angelo or a Raphael, the superb statues of a Phidias or a Praxiteles, the chaste and elemental lines of the Greek Temple, the heaven pointing spires and arches of the Gothic Cathedral, are non-existent. He is restricted to the brief and fleeting delights of music and song.

A recent war picture has depicted the horror of sudden blindness. A soldier has been suddenly deprived of sight by a chance bullet. He is kneeling on the grass, his gun dropped hopelessly by his side, his face turned upward in infinite despair, the backs of his hands pressed helplessly against his wounded and darkened eyes. The picture excites a throb of pity in the hardest heart. The artist has well depicted the greatest misfortune imaginable. In an instant to be plunged into life-long darkness — never to see the glorious day again!

Those who are born blind have no possible sense of what light and color are, what sensory vision is like; they do not even realize what darkness is — they cannot feel what they miss. The blind man had heard of blue Monday; he thought

that blue was like Monday; he had absolutely no appreciation of color sensation of any kind.

The civilized world is becoming more and more a world for the seeing person. Even the country roads are no longer safe for the blind man owing to the silent, swiftly running automobile. Books, magazines, and newspapers open up the whole range of knowledge to the mind through sight. The moving picture show displays the world and brings comedy and tragedy to all who can see. The popularity of the moving picture show indicates the enormous appeal that can be made through the eye alone. The moving picture play is the deaf man's play and yet that does not lessen its popularity. Could public phonograph entertainments rendering music or the words alone of plays — which would be the blind man's entertainment — ever draw the crowds and have the popularity of the moving picture show?

The eye is rightly called the window of the soul. When you really want to know what is in another's mind you ask him to look you in the eyes. All other sense organs are hidden and unresponsive. The inner ear, the taste, the touch organs are unseen, and the outer ear is a mere immobile fold of cartilage, unchanging in man under his deepest emotions. But the eye is ever moving, changing

and adjusting, bright now with joy, sodden again with grief, bloodshot in rage; now the lowered or sidelong glance of love, again the open and far-off gaze of childish innocence. The eye itself, brown, black, blue, gray, hazel, green, is an object of great beauty and seems a proper organ through which to get our stimulations for color and light sensations.

The rank of vision as a sense will be shown by the fact that the largest per cent. of people are of the visual or eye-minded type and remember and think, dream and imagine in images of sight.

A good deal is known about the eye and about vision. The story of the mechanism of the eye and of the processes that take place in the transformation of the delicate and intangible ether waves in the outer world into sensations in our minds of light and color, the study of how the mind works over this visual material into a wonderful inner world of space perception, is a fascinating one, a story that we must confess can only as yet be partially told — but a story of interest to every seeing person. We hope to be able to tell that story in a way that will excite the attention and inspire to further reading and study, and lead to a better appreciation and care of the organ of sight and a better training and education of the visual perception.

CHAPTER II

THE EYE AS A VISUAL APPARATUS

THE richness, variety and bigness of the world we live in depends directly upon the number and perfect adaptability and working of our sense organs. If any sense organ is lacking or defective, just to that extent do we lack knowledge and appreciation of the outer world. Without sense organs we would never have an idea. No mental life or mind could ever develop.

Psychologists no longer hold the doctrine of innate or inborn ideas but believe thoroughly in the idea propounded by Locke and his followers, that nothing is in the intellect that did not first come through the senses. The outer world is thought to be composed of numberless molecules, the vibrations of which affect our various sense organs, thus furnishing us with the raw material with which the mind, through sense perception, builds up the beautiful world in which each one of us lives. As Schopenhauer so aptly put it, "The world is my representation."

There are undoubtedly many vibrations and forces in the outer world of which we are absolutely unaware, as far as our direct sense experience goes, but it is likely that these outer activities are of no particular consequence to our welfare, or we would have developed sense organs for them. We have all the sense organs we need to adapt ourselves to the world and more and keener senses would be very disconcerting and distracting. Nature is inclined to be parsimonious and does not give us any more physical apparatus than we need and use.

A sense organ may be defined as a mechanical or a mechanical-chemical apparatus whose function is to transform outer vibrations into sensory nerve currents. Each sense organ is susceptible to but one order of stimulation.

The organ of vision is the eye, which may be thought of as a living self-adjusting camera, whose function is to transform the vibrations of the ether molecules, which are supposed to fill all space, into optic nerve currents, which, running to the visual brain cells, give us the illuminating, entrancing sensations of color, light, and shade that we have, and reveal to us the beauties of the outer world.

All living matter is more or less susceptible to

light. Note how the plant in a cellar grows toward the light and the lower one-celled animals, like the amoeba, are affected by light, although they have no special organ for it.

The next step in the development of visual sensibility, after general external susceptibility to light, is the development of the so-called pigment spots upon certain parts of the bodies of lower animals, which spots have a special sensitivity to light. These spots are the primitive eye and are modifications of the skin, and it is interesting to note that the eye, even in its highest form, with the exception of the retina, is a complex development of the same layer of embryonic cells from which the skin develops. The story of the evolution of the eye from the primitive pigment spots in the lower animal forms, up through the vertebrates to man, is a long and interesting one. There are the many faceted, non-adjustable compound eyes of insects; the flat, slightly adjustable, short focused, absolutely divergent eyes of the fishes and reptiles; the divergent, non-parallel but more adjustable and far-seeing eyes of the birds and most mammals; until finally we reach the perfectly converging, automatically adjusting eyes of man. The human eye embodies the best points of the eyes of the lower animals and few of the defects, having a

keenness and power of adjustment for both near and far objects far surpassing the eyes of the animals.[1]

The anatomical structure of the eye has been fully described in numberless anatomies and physiologies and it is not necessary to give anything but a simple and brief account of its structure and mechanism in a work of this character. The subjects of anatomy and histology are very broad and complex and the psychologist cannot claim to be anything but a layman in these fields, but in order to discuss vision intelligently we must use a good many terms relating to the structure and mechanism of the eye, hence a plain and simple account seems desirable here.

More than any other sense organ the eye may be thought of as a direct outpost or watchman for the brain; as Dr. George M. Gould says, "The brain comes out to see, the cerebral substance is pushed outward to make the essential part of the retina."

"The essential receptive part of the eye is in the retina," says C. Judson Herrick, "but the retina is much more than this; it is really a part of the

[1] If the reader is interested in the evolution of the eye he should read the article by Edward A. Ayres in *Harper's Magazine*, Vol. 117, p. 601, etc., entitled "Eyes and Vision from Worms to Man."

brain, and the so-called optic nerve is a true cerebral tract." All the mechanism and refractive media of the eye are for the purpose of focusing clear cut images from the outer world upon this sensitive outpost of the brain called the retina. The retina occupies the same place in the eye that the film does in a camera, but it does more than the film; it not only receives and is affected by the images from the outer world, but it also transforms these light waves into nervous impulses, which are carried by the optic tract to the brain cells in the visual centers of the cerebrum.

The retina, however, essential to seeing, would be of but little more use than the photographic film would be without the focusing lens and other mechanism of the camera. An animal with a retina and optic tract but no other part of the visual apparatus might be able to distinguish light from darkness and perhaps get some vague color sensations, but certainly could never get any ideas of the form, distance, or direction of objects. The retina alone would be little more than a highly specialized pigment spot sensitive to light. On the other hand, all the complicated mechanism and various refractive media of the eye would be useless apparatus without the retina.

Perhaps a few details of the structure of the eye

and the relation of its parts would be of interest.

The eyeball is of spherical shape somewhat flattened from front to back, being about one inch in its transverse diameter and about $\frac{9}{10}$ of an inch in its longitudinal diameter. Set in its bony orbit and with the eyelids and eyelashes it is quite well protected from injury. The tear glands furnish the fluid, which by the movements called winking, keep the surface of the eye moist and clean, the excess of tears being carried off by the tear ducts. Sometimes, as in weeping, the secretion of tears is excessive and they overflow down the face. The same overflow is sometimes seen when the tear ducts are clogged. The eyeball is a surprisingly strong structure and will stand hard blows and pressure, or jars, without permanent injury, and may sometimes be partially pushed out of its socket without bursting.

The eyeball is made up of three layers or coats containing (see Fig. 1) the lens and the humors of the eye which are transparent and refractive. The outer sclerotic coat composes the white of the eye and is of dense, tough connective tissue. In front it merges into the cornea, which is a horny, transparent substance and may be thought of as the window of the eye since through it light

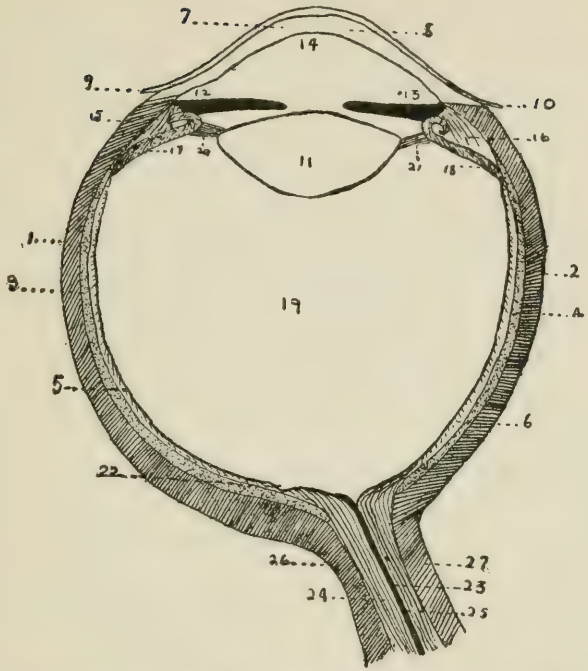


FIG. 1.— Diagram of the left eye. 1, 2, Sclerotic coat; 3, 4, Choroid coat; 5, 6, Retina; 7, 8, Cornea; 9, 10, Conjunctiva; 11, Lens; 12, 13, Iris; 14, Anterior Chamber; 15, 16, Ciliary Muscle; 17, 18, Ciliary Process; 19, Vitreous humor; 20, 21, Suspensory Ligament; 22, Fovea Centralis; 23, Artery; 24, 25, Optic Nerve; 26, 27, Optic Nerve Sheath.

shines upon the lens. Both the cornea and sclerotic coats are covered with a smooth, thin layer called the conjunctiva, so that the eyelids, lined inside with the same substance, move over the front of the eye easily.

The second coat of the eye, called the choroid, is a loosely made coat composed mostly of blood vessels and connective tissue, and on its inner surface it contains many dark pigment cells. Towards the front of the eyeball this coat is plaited, forming the ciliary process, and then it changes into the iris, which is the light curtain that regulates the amount of light entering the eye. The iris is what gives the eye its color, the color depending upon the amount of pigment in the iris. The opening in the center of the iris which contracts and expands as light increases or wanes is the pupil, through which all light enters the eye. The iris in its adjustment to the light is entirely automatic. As the light grows bright the central or circular muscle of the iris contracts and the pupil becomes smaller, and as the light decreases the iris relaxes, or rather is drawn back by its radiating muscles, and the pupil enlarges. This adjusting power of the iris prevents over-exposure of the retina to light, and makes it possible for the retina to be affected by dimmer lights also, which would be impossible without more exposure as the light grows dimmer. The iris is a much more delicate light controller than the light adjustor of a camera, for it changes automatically to every change in the amount and brightness of the light.

The pupil of the human eye is round and may decrease to a pin point or increase to a circle one-half an inch or more in diameter. Some eyes, as for example those of the cat, narrow to a slit in intense light. But in all cases the action is automatic and unconscious.

The third and inner coating of the eye, which covers all the inside of the ball up to and around the iris, is called the retina. This, we have said, is the essential seeing part of the eye upon which light is focused and in which those mysterious processes take place that transform ether vibrations into nerve currents. The retina is an exceedingly complicated nervous structure. It is, as we have said, a modification of the optic tract, rendering it susceptible to light. The optic nerve fibers entering the back part of the eyeball turn outward from the innermost layer of the retina and form the retina, composed of nine layers of nerve cells and fibers and supporting nerve matter. The ninth layer — so-called — is composed of what are known as the rods and cones, which are elongated nerve endings, some of them like minute rods and some like small cones. (See Fig. 2). The rods are about $\frac{1}{14,000}$ of an inch in diameter, and the cones about $\frac{1}{10,000}$ of an inch. There are, it is thought, about 500,000 optic nerve fibers running

between the retina of each eye and the visual brain centers. It used to be thought that there were altogether only 500,000 rods and cones in each retina — that is, a rod or cone for each optic nerve fiber, but according to some modern writers, there are at least 6,000,000 cones and about 130,-

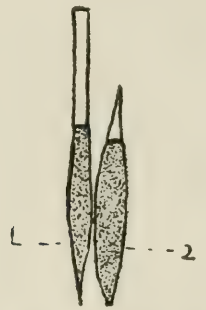
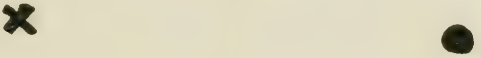


FIG. 2.— 1, Retinal Rod; 2, Retinal Cone, greatly enlarged.

000,000 rods in the adult retina. Some, however, make the number much less. Dearborn says there are seven cones and a hundred rods connected with each one of the 500,000 optic nerve fibers of the retina. This would indicate that there are about 3,500,000 cones and about 50,000,000 rods in each retina.

It would appear, then, that the retina is capable of receiving light from 500,000 distinct points, enabling us to sense two points in space as two,

the light rays from which fall on the retina at a distance apart so small as to be incomprehensible to our imagination. The rods rest against the outer layer of the retina, called the pigment layer, which lies next to the choroid coat of the eye. The optic tract itself is insensible to light. The spot where the optic nerve fibers enter the eye is entirely blind. This can easily be proved to the reader if he will close his left eye and look steadily at the cross below with his right eye, then move the page slowly back and forth in a straight line from the eye until the



black spot disappears. It disappears, as can be proved, when it falls on the spot where the optic tract enters the eyeball, showing, at least, that the retina is the necessary transformer of light. By holding a lighted candle to the side of the eye in a darkened room, we can illuminate the inside of the eye, and get a beautiful picture of the blood vessels of the retina, proving that the seeing elements are back of the blood vessels of the retina, and from their mosaic structure and sensitivity to light presumably in the rods and cones.

About $\frac{1}{10}$ of an inch outside of the spot where

the optic nerve enters the eyeball we find the yellow spot which is about $\frac{1}{24}$ of an inch in diameter. This has a depression in its center called the fovea. This is the spot of keenest vision; the image of any object must fall on this spot to give a distinct impression. This spot contains retinal cones but no rods. As we go out from this spot towards the sides of the retina we find fewer cones and more and more rods. We find also a gradual decrease in the clearness of the images which fall on the sides of the retina. The center of the retina, then, is for clear vision, the sides for warning of danger and attracting attention, causing us to move our eyes so as to get clear images of the moving or interesting object, vaguely caught sight of through the sides of the retina.

We have yet to mention the apparatus for accommodating the rays of light from various distances to the retina. In a camera this is accomplished by moving a solid, unchangeable double-convex lens back and forth until a clear image is cast upon the sensitive plate. It is obvious that the double-convex lens of the eye, since it is inside the eyeball firmly swung by the suspensory ligament just back of the iris, cannot be pushed back and forth to adjust to near and far objects, neither

can the eyeball shorten or lengthen, as was once thought; neither can the refractive media of the eye besides the lens, viz., the cornea, aqueous humor between cornea and lens, and the vitreous humor between lens and retina, change their refractive powers. Hence we must place the accommodation power in the crystalline lens.

Here is seen one of the most beautiful examples

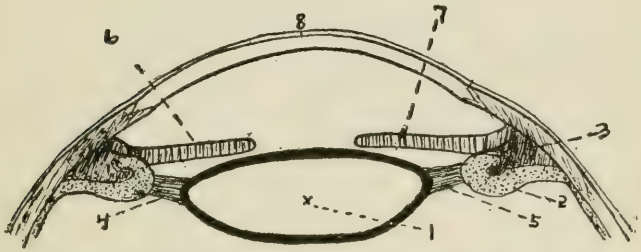


FIG. 3.— Diagram of Anterior Portions of the Eyeball, showing the lens and its accessories. 1, Lens; 2, Ciliary Process; 3, Ciliary Muscle; 4, 5, Suspensory Ligament; 6, 7, Iris; 8, Cornea.

of unconscious automatic adjustment. The lens is naturally elastic, like a hollow rubber ball. It is normally kept somewhat flattened by the suspensory ligament which suspends the lens, and is attached to the hyaloid membrane of the vitreous humor. (See Fig. 3.) Hence the lens is usually adjusted to distant objects, but when the eyes are turned upon nearer objects the ciliary muscle,

which is attached to the eyeball all around where the sclerotic and cornea join, pulls the choroid back of the ciliary processes which are attached to the suspensory ligament, up and inward, thus releasing the tension on the lens. The lens, therefore, grows more convex, especially on its front side, bending the rays of light more than when flat and thus keeping the image on the retina clear and sharp. The writer heard a report some years ago of a case of a young woman who claimed that she had voluntary control over the accommodation movements of the lens, and could at will bring the horizon up to her or by voluntary relaxation put near objects off into the horizon. Ordinarily, however, all this adjustment takes place involuntarily, and we only know that we see objects clearly both near and far, and that we can never tell from our feelings alone, how it is done.

Not only does each eye have to accommodate itself to distance but the two eyes must automatically converge more or less, as the object is near or far. This is also a purely automatic adjustment and upon its accuracy depends whether one clear impression is obtained from the two eyes or a confused or a double image.

The convergence and also the turning and roll-

ing of the eyes about in all directions in their sockets is accomplished by the eye muscles. There are six of these muscles for each eye, four straight muscles, one above, one below, and one on each side of each eye, arising from the base of the eye socket where the optic nerve enters, and merging into the sclerotic coat and ending near the cornea. There is also for each eye the superior and the inferior oblique muscles which aid in rotating the eyeball in various directions.

CHAPTER III

LIGHT AND COLOR SEEING

THROUGH the eye as a visual apparatus we get the excitations for sensations of color, light, and shade of many different kinds and intensities.

The question of what light and color are from the standpoint of physics is a very intricate one and can be but briefly touched on.

To say that light and colors do not exist, to the full, except in the minds of sentient creatures, is to make a statement which at first excites incredulity and astonishment in the mind of the hearer. The sun seems to us to flood all space with beautiful white light and the world appears to be full of most beautifully colored objects of all degrees of brightness and luster. Even physicists, however, admit that color, light, and shade are, in their last analysis, inner sensations. Lewis Wright says that color and light, as we see them, are purely matters of sensation, or subjective consciousness. The color and light sensations in our minds are the subjective side of the

phenomenon we call light, the ether molecules and their vibrations are the hypothetical objective side. Ordinarily when we speak of color or light we mean to include both the inner subjective sensations and the external objective cause of these sensations.

We read in Genesis that the earth was without form and void and darkness was upon the face of the deep, and that the spirit of God moved upon the face of the waters; and God said let there be light and there was light, and God saw the light, that it was good; and God divided the light from the darkness. But until sentient creatures appeared with eyes and minds capable of sensations there was really no light or color on earth except to the All-seeing Eye, and in the sense that some day such creatures might become aware of light and color.

The basis for our sensations of light and color is not thought by modern physicists to be a substance, or a thing, even from the physical standpoint. It is a process, a condition, a wave, a propagation of motion through space. This is neatly illustrated by a familiar experiment in physics. In a groove a number of marbles are placed touching one another. Then by pushing the marble at one end the marble at the other extreme will be

almost instantaneously moved, and yet the original marble has traversed but little of the intervening space. A wave of force has run along from marble to marble, we say, much quicker than the originally moved marble could traverse the intervening space. Our eyes are the organs that take up vibrations at the end of a wave and transform them into nerve excitations causing brain cell motions, which our minds, in an inexplicable and miraculous way, sense as light or color.

The whole of space is thought to be filled with almost infinitely small molecules, called ether molecules, which are easily set in motion by explosion of gases, or by vibrations of heat or other molecules. These ether molecules vibrate with extreme rapidity in a plane transverse to the direction of the progress of the wave. No ether molecule moves forward, but excites all other molecules of ether around it, and they vibrate in the same way. Thus the wave progresses and moves in all directions, as from the center of a sphere. These ether waves move at the immense rapidity of about 186,000 miles per second.

The distance any light wave travels will depend upon the force and bigness of the original excitement, just as does the bigness of the waves

in the water caused by a stone thrown into a pond, or the intensity of the waves in the air caused by some vibrating body or explosion, depend upon the bigness and force of the initial cause.

Our greatest original source of ether vibrations is our sun. The force of the disturbances in the sun may be vaguely imagined when we consider that the light waves traverse the 90,000,000 miles between the sun and the earth in about eight minutes. Measured in terms of light velocity the sun is only a few steps from the earth. Some fixed stars are so far away and cause ether waves of such intensity that the light from them takes hundreds of years to reach us, and the stars themselves may have gone dead and cold centuries before we see them.

The colorless or white light that we get from the sun seems to us to be a simple and unanalyzable sensation, and yet all our color sensations can be obtained from the analyzing of white light into its component waves. White or colorless light is simple psychologically but extremely complex physically. It is a complex wave, resultant of many vibrations of ether molecules at different rates. The total wave of white light, or indeed of any colored light, moves forward at the uniform rate of 186,000 miles a second, although

the transverse vibrations differ in length and rapidity.

Light waves tend to move in straight lines from the original centers, unless diverted, reflected, absorbed, or dispersed by coming into contact with some other kinds of molecules. The pure white light that seems to be simple in quality to our senses is really, as we have said, extremely complex, and can be analyzed physically by a trian-

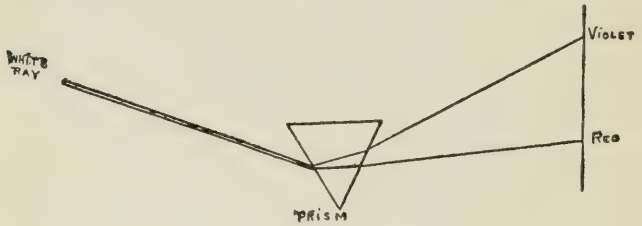


FIG. 4.

gular prism into all the colors of the rainbow. Since there are vibrations at many rates in the so-called waves of white light, when such a ray is thrown onto a triangular prism the component waves are differently refracted or bent (see Fig. 4), hence they are separated and may be seen on a screen as spectral colors, in the order of their refrangibility. The red ray is least diverted, and the colors appear in a certain order up to violet — red, orange, yellow, blue, indigo-blue, violet, the

violet being the ray whose molecules vibrate the shortest distance and the fastest. Hence the different colors that are seen are caused by the different rates of the vibration of ether waves per second. What is quality in our senses is only quantity or number of ether vibrations in the outer world, and there is no possible likeness between ether vibrations at the rate, for example, of three hundred and ninety-two trillion vibrations of ether molecules per second, and the color red that we get from this rate of vibration, or between seven hundred and fifty-seven trillion vibrations of ether per second and the sensation of violet, which we get from that rate of vibration. Vary the rate of vibrations of ether between the above limits and we get in our minds the different color sensations displayed by the spectrum, from red through all the different shades, up to violet. There are undoubtedly ether vibrations below the red of the prism and above the violet, but they do not affect our eyes or give us any light or color sensations. Our eyes are affected only by a very narrow range of differing rates of ether vibrations. There are at least one hundred and fifty different tones or shades of color distinguishable in the spectrum. Not only are there the one hundred and fifty different spectral colors, but by mixing the red and

violet lights that form the ends of the spectrum, purple is produced.

We find also that the brightness or intensity of light affects our judgment as to its color tone. If the intensity of a colored light is decreased it passes through many shades of color to black. If the intensity of any colored light is increased or more and more white light is mixed with it, it passes through many tints to white. By thus increasing or decreasing the brightness or intensity of colored light we get at least 30,000 different shades, each of which is to the eye a simple color sensation, not mentally analyzable. If white light, or what is generally called colorless light, is decreased we get an almost incalculable number of shades of gray down to black. Black is the psychological opposite, then, of all kinds of light, both colorless and colored, and is a positive sensation and not a merely negative state. Although, physically it is a lack of vibrations of ether, mentally it is a positive state, due evidently to the recuperation of some retinal substance which is decomposed or affected by light.

From what has been said heretofore about the subjective side of light and color it will be understood that objects in the outer world are not colored in themselves, but different objects, owing

to their different molecular structure, reflect or absorb the colorless complex light of the sun differently. A red object is one that absorbs all the vibrations except those at the rate of three hundred and ninety-two trillions per second, and so with different objects differently vibrating light rays are reflected giving us sensations of the various colors which we ascribe to the objects in space and think of them as having actual objective qualities called colors. Besides reflected light there is also original light from other sources than the sun; from burning gases, incandescent electric lights; from heated or burning substances of many kinds. The molecules of each gas or substance when heated or burned vibrates at a certain characteristic rate, starting ether waves which cause in us sensations of light or color.

We speak of the colors red, orange, yellow, green, blue, indigo, and violet, as the principal colors, although we find that the spectral colors are continuous and that we can distinguish one hundred and fifty different shades, each one psychologically a simple sensation to us. The naming of the above colors as the principal colors was first suggested by Newton, in imitation of the musical scale, but just why we should pick these colors out of the one hundred and fifty colors dis-

tinguishable in the spectrum is an interesting psychological question. The above mentioned colors are the principal ones only because we for some mental reason see them as such. They seem to stand out to us from all the other colors. It appears to be really a matter of mental apprehension or apperception. We see these colors because they are the chief colors experienced by us in nature. The red of blood and of the setting sun, the orange and yellow of the ripening grains and of the desert sand, the green of the trees, the blue of the sky, the indigo blue of the sea, the violet of the flower and of the cloud. If the colors of the objects that are most prominent and common in nature were different we would apperceive a different set of principal colors in the spectral series. Some writers claim that ancient man was more or less color blind. This idea is based on the fact that in the Homeric poems and other early literature only four colors are mentioned, but this may not indicate lack of color sense but a lack of discrimination. The four most prominent colors in nature, of the seven we have mentioned, are red, yellow, green, and blue. Indigo-blue and violet are somewhat less prominent, and although they may have been discriminated they were not especially named until, as Wundt says, " they were

needed for optical and technical purposes." Wundt also adds that " it has been quite recently proved that the scale of color sensations in various savage races presents no differences from our own." A. Henry Savage Landor relates in his book " Among the Hairy Ainos," how he once squeezed some light blue pigment into the palm of the hand of an Aino, and how the savage rubbed it out over the palm and yelled and leapt for joy. If we think of the tattooing and color decorating that savages display we will be convinced that they have a color sense somewhat developed, although they may lack names for all the different shades. It is however claimed by many writers that man is growing more and more discriminating and sensitive to color differences.

It has been mentioned that white light is always a complex wave, and when analyzed by the spectrum gives us the one hundred and fifty spectral colors; these may be re-combined and give us again a sensation of white light. Thus, although white is a very complex ether wave we do not sense the complexity. There are other combinations of light waves that will give us a pure sensation of white or gray. In general, every color wave near one end of the spectrum will mix with some other color wave at the other end and give

us a sensation of white, which to us, as a sensation, is pure and not sensed as a compound. These pairs of color waves, which mix and give us white, are called complementary colors, e.g., red and greenish-blue, orange and blue, violet and yellow, are color pairs which, when their waves are united, give us white or gray. The mixing must be mixing of the light waves, either by the use of the prism light or by the use of colored discs upon a color wheel or top. Pigment colors in such pairs when mixed, do not give us white.

These complementary colors are harmonious and pleasant when they are seen side by side. One seems to be a rest to our retinas from the stimulation of the other, whereas contrasting colors, as for instance yellow and red, green and blue, yellow and green, when seen side by side are very tiresome and discordant to us. These latter are evidently all destructive to the retinal color substances. The colors that are near each other in the spectrum are unpleasant when seen together, while those widely separated are pleasant when seen side by side.

Savages and primitive peoples like the glaring contrast and disharmony of the contrasting colors rather than the harmonious feeling that more civilized people find in the relations between the com-

plementary shades. Being less delicate in their nervous and sensory reactions savages and uncultured peoples probably find the vivid color contrasts and the more exciting sensational results more pleasant to their less sensitive nervous systems. Nowadays, if a great many women were judged by the colors they wear they would be thought either color blind or more or less savage. Perhaps our modern strenuous life makes us demand excessive contrast and exciting stimulations, but it seems more likely that the present style of wearing combinations of glaringly discordant colors is only a passing phase of fashion in its search after the bizarre and the sensational.

It is easy for any one to find out what colors are complementary and therefore harmonious, owing to the beautiful phenomena called " after images." If we take a small red card or a piece of cloth, for example, and place it upon a white back-ground, and look at the red steadily for thirty to sixty seconds, then drop the red piece and look steadily at the spot on the white background where it was, we will soon get a beautiful after image, seemingly in that spot, of the color complementary to the red — in this case a bluish green. This is the color harmonious to the original stimulation.

The retina, chemically decomposed by the original stimulus, gives us the complementary sensation when the original color is withdrawn, evidently as a result of the retinal substance rebuilding. Many times we observe this phenomenon when we look at the yellow setting sun and then look away to other parts of the sky and see the bluish discs called harvest moons, which are often a matter of superstitious portent to people ignorant of the phenomena of after images.

After experiencing any color sensation we have then in a short time an after image of the complementary color, and this fact is closely connected with what are called "contrast effects." If a neutral gray slip of paper is placed upon a white background the gray will appear darker than usual. If the same gray slip is placed on a black background it will appear lighter than in the first case, or than when viewed without a background. Place the same gray upon a blue background and it will appear to be of a yellowish tinge, and when placed upon a green background it appears to be of a reddish color. These effects will be heightened by laying a piece of white tissue paper over the gray slips when placed on the different backgrounds. These effects are somewhat hard to explain; the cause is probably both physiological and

psychological. The building up of the retina after decomposition, giving us the complementary shade, may affect the sensation given us by the gray slip in each case. And again, our mental apprehension of any sensation is altered by what has gone before, according to the psychical law that no sensations are absolute in quality and intensity, but are always relative to what other sense experience is present or has just preceded. These so-called contrast effects have a bearing on decorations and dress. All have observed how black a negro looks when wearing white clothes; a negro woman's face would look less black if she wore black — or any other color than white. The same would apply to dark brunettes; they should not wear white clothes or hats, unless they wish to accentuate their dark complexions. If the brunette is of a rather pale or grayish complexion she could wear green to advantage, as that will tend to make the face appear more rosy. This is seen in the charming effects of a green parasol in such cases. She should, however, avoid red or blue, for according to the contrast effects noted above, red clothing, hat and parasol, will make the face appear greenish, and blue will give it a yellowish tinge. The golden haired, rosy cheeked blonde can wear white, although it will somewhat

dull the brilliancy and brightness of the hair and face. Black will accentuate her complexion. Blue will make the yellow hair seem still more yellow and will not aways harmonize with the rose and white complexion, since it will tend to give it a yellowish tinge, and yellow and red are discordant. If the blonde be of a pronounced reddish hair and complexion she should not wear green unless she wishes her face and hair to appear still more red. The pale, neutrally complexioned blonde, however, could wear green to good advantage, while red, blue, or yellow would be doubtful.

It has been mentioned that sensations of white light are obtained by mixing all the color waves from the prism, and also by mixing any two complementary color waves. Pure white sensations are also produced by mixing red, green, and violet light waves. By varying the amount of these light waves, in their relations to one another, every color sensation possible from the complete prism may be caused. Hence these color sensations are often called the fundamental ones — not because they are any more important to us as sensations than any other colors, but because the physical bases will combine and give us sensations of all the colors, and no combinations of other

color waves will produce any of these three so-called fundamental color sensations.

The possibility of getting all other color sensations by mixing the three fundamental colors, red, green, and violet, is true of about ninety-five per cent. of males and practically of all females. In other words, only about five per cent. of people are color blind. We find people who are color blind to red or green or violet; mostly, however, to red or green. There are very few cases of violet color blindness. The person color blind to red, Scripture says, will see all reds and yellows as some shade of green. The person color blind to green will see all greens and reds as some shade of yellow. Evidently the person who is color blind, either to red or green, is not fitted for railroad, steamboat, or automobile service, or any work where light or color signals are used. Red commonly means danger and green means safety, but a person color blind to either red or green cannot distinguish between these two colors. As we have said, if he is color blind to red all reds will be seen as greens, and if color blind to green all greens will be seen as yellows. There are sometimes cases of total color blindness, that is, everything appears as some shade of gray, sometimes light, sometimes dark. The whole world looks

like a photograph and is entirely lacking in the variety of colors that the normal person experiences. It might be surmised, as some writers do, that some sets of people, as for example the Quakers and the Dunkards, are more or less color blind or they would not be content to dress in gray or brown clothes. The beautiful color sensations most people get from nature evidently are but feebly experienced by them.

Perhaps the reader will be surprised to learn that he himself is color blind in certain portions of each retina. All objects at the extreme outer limits of the visual field of each eye appear gray, whatever their color. As we bring objects of different colors more towards the center of the visual field, we notice first blue, then yellow, then red, then green, then all colors in the center of the visual field. The retina is evidently sensitive only to colorless light in its outer zone, inside of that zone is a part sensitive also to blue, next yellow then red and green, and finally the central part susceptible to all kinds of colored as well as colorless light. The central circle of the retina is mostly composed of cones, while the outer zones are composed of rods, the number of cones decreasing and the number of rods increasing towards the outer zone of the retina.

Our knowledge of the processes which take place in the transformation of the light waves which enter our eyes, into optic nerve currents is still quite unsatisfactory. There are several well-known theories, such as the Young-Helmholtz theory, the Hering theory, the Franklin theory, etc., but space does not permit a statement of them here.

The outermost layer of the retina, as has been stated, is the so-called pigment layer against which the rods terminate. The rods and cones are the undoubted transformers of light into optic nerve currents. Light falling on the retina passes through the first nine layers and bleaches the visual purple of the pigment layer. It has generally, until quite recently, been supposed that the bleaching of the visual purple caused excitations of different rods and cones, and thus gave us the bases for our sensations of different colors and shades. This may be true of our sensations of colorless light for the visual purple cells derived from the pigment layer are found to be connected with the rods but not with the cones. The outer zone of the retina which is especially sensitive to faint light and to grays is composed altogether of rods. But towards the central zone of the retina the number of cones increases and the number of

rods decreases, until the yellow spot is reached, where there is found only cones, and yet the whole retina, even at the yellow spot, is sensitive to white and all shades of gray. It would therefore seem evident that the cones as well as the rods are sensitive to excitations by colorless light, and yet the cones have no visual purple or rhodopsin connected with them. It is also confusing to find that the retina of pigeons, fowls, and many reptiles are mostly, if not entirely, composed of cones and contain no visual purple. There are nocturnal animals also that have no retinal rods, but only cones, hence no visual purple. This seems queer if rods and visual purple are the retinal parts especially susceptible to shades of colorless light. Among human beings the eyes of Albinos are lacking in the pigment layer and hence in visual purple, and yet they can distinguish light and shade as well as color although likely to be dazzled and somewhat deficient in seeing, indicating the pigment layer is of advantage, besides a possible transforming function, in preventing confusing reflection of light in the eye.

In regard to the cones of the retina the most common assumption is that they are the color seeing apparatus. But just how light excites them is not really known. As is suggested heretofore,

they have no visual purple in connection with them, the bleaching of which might excite them in a chemical way, and yet the parts of the retina which are composed largely or entirely of cones are the color seeing parts. It may be assumed, as Ladd does, that the cones have some colorless pigment cells connected with them, the chemical decomposition of which furnishes the different excitations of the cones which gives us sensations of the different colors which we get, but this is only an assumption for which we have no experimental evidence from histology.

The writer, notwithstanding the confusion of evidence, is disposed to the view that the retinal rods are sensitive only to colorless light, the shade of gray depending upon the bigness of the vibrations of the ether molecules, while the retinal cones are sensitive not only to colorless light vibrations, but also in some unknown chemical way, are differently excited by the differing vibration rates of ether which are the bases of color. The brightness or intensity of the color sensation depending here also upon the amplitude of the ether vibrations. This would imply that each cone is sensitive not only to light intensity but also to the different numbers of ether vibrations per second. Some writers claim that each cone must

have at least three color substances, one susceptible to the red vibration rate, one suceptible to green, and one to violet, these being the basic colors. All other color sensations are produced by the varying degrees of excitation in these three substances. At the same time it must be admitted that each cone is capable of giving excitations of white and gray. We have, however, as mentioned, absolutely no knowledge of what the so-called color substances are.

The interesting fact, however, to remember is that our retinas are so constructed that they can send nervous excitations to our brains, which excitations differ as the number and intensity of the ether vibrations differ, and that our minds apprehend these differing brain cell excitements as colors, or white, or gray. Whether one person's red, or green, or blue, is exactly similar to another person's red, green, or blue, can never be known. A primary simple sensation like that of red can never be described or made known to a person who has never experienced it.

CHAPTER IV

HOW WE LEARN TO KNOW THE OUTER WORLD THROUGH VISION

OUTSIDE of us spreads the complex and variegated outer world, with an almost infinite number of objects of different kinds, sizes and colors at varied distances from us. Within each one, speaking popularly, is that wonderful activity called the mind which learns to know this outer world and to act and react toward it for the individual's protection, happiness and growth. Presenting the outer world to the mind are the sense organs, without which the mind could never know the multiplex outer world.

What space is in itself is problematical, but at least it seems to us a real something in which objects of all kinds and sizes can move and react. It makes material existence of objects possible. If we try to imagine all material things annihilated, including our own bodies, we feel that space would still exist, although it would be, perhaps, merely the empty possibility of extended objects

and their movements. It is often said that Nature abhors a vacuum, and so also does the mind, for the scientist, as we mentioned in the last chapter, thinks of so-called empty space as being filled with imponderable ether.

The problem of how the child learns to know objects in space of different kinds and sizes and at different distances away, and in different directions, is a very complex and difficult problem and somewhat hard to make plain. It appears certain that at first we have little or no ideas of objects in the outer world or of their space relations. We do not open our eyes, when newly born, and see an outward world of objects in space. We have to build up our idea of the world by a long and complicated process. For this process vision and touch furnish most of our material, but vision soon assumes the most prominent rôle, using touch as a helper and confirmer of its conclusions. There have been instances of adult people who have received their sight after having been blind from birth, and according to their testimony the world appears utterly strange and incomprehensible, at first, to them. The objects that are familiar to them through touch are not at all recognized by them through sight, but must first be touched. One such person did not

know his favorite cat from an elephant until he touched it. In cases like these the objects in the outer world seem like blotches of undiscriminated colors touching the eyes and there is no idea of distance, relation or size; all is one big confused mass of undiscriminated color, light, and shade. As in the case of the blind man described in the New Testament, who was cured of his blindness and saw "men as trees walking."

It would be a legitimate inference that the child is even less able at birth than the adult who has received his sight to discriminate objects or tell anything about size and distance, for the child is color blind for some time, and his eyes do not for several weeks converge or accommodate themselves to distance, and he has no trained touch, or muscular sense to help him in his space perception.

As mentioned in Chapter II, the mind does not simply receive pictures or reflections of natural objects through sight. It receives only certain excitations through the eye and the brain, which are but the raw materials which the mind must work over into the intricate and wonderfully varied forms which we ascribe to the outer world. The mind, then, is a superb artist, a real creator of the picture each one has of the outer world.

Visual sensations are the raw material — our idea of a world in space is the completed product. The building up of such a world in each mind is that activity we call perception. The development of perception is the principal mental activity of the first years of life, and upon its degree and manifoldness of development depends all our future mental power and possibility. If an adult looks at a tree and gets the sensations of a red spot in the midst of green leaves he has more than mere sensations; he sees, perhaps, a red bird, of a certain size, amongst the green leaves of the tree, at a certain distance away, and in a certain direction. The small child, however, looking at the same objects probably gets only red and green sensations; he does not perceive a red bird in a green tree; he does not perceive the size and distance and direction of the bird or the tree; he has not yet learned what the visual or the muscular sensations mean that he gets through his eyes and his eye movements.

Our question, then, is how do we learn what colors, lights and shades gotten through the eyes and the muscular sensations from convergence, accommodation and moving of the eyes, mean.

The Ancients thought that real little images or replica floated off from all objects and passed into

the brain through the eyes, and thus we saw the world through the small bodies, but this idea is a purely fanciful and untenable one. We do not see the world as it is, but each person sees it according to his own interpretation, and the world each person sees is different, to a degree, from the world that every other person sees. While the excitation comes from without the meaning comes from within our own minds, as a result of former experience and observation. We learn to distinguish between different objects by their different sensory qualities. All the senses help us in this discrimination but it is the discrimination through seeing that is of especial interest here. A visual object is known to us only by the sensation of color and shade that it gives to us. Objects are distinguished between because they are of different colors, thus their boundary lines are distinguishable and when seen again they are recognized. A number of objects of exactly uniform colors would be indistinguishable one from another to us through sight. We would have to touch each one to distinguish it. So, through the visual qualities of objects called color, light, and shade, we learn to tell one object from another, and to know a certain object again when we see it. In estimating the shape and size of an object we

are probably helped by the eye movements made in looking it over and running our eyes around its outline, but as will be seen later, estimation of size is closely related to the distance an object is thought to be away.

The eyes are finely constructed for giving us the location and direction of objects and points in space. For a person who has two normal eyes the possible visual field in any position of the head, to right and to left, is at least 180°, and by turning around we can take in at once all the rest of the possible visual field. Of course in the visual field seen by us at any one time there are almost numberless points in space; straight ahead in the center of vision, to the right and left, and above and below, and for any proper dealing with space we must be able to tell the directions and locations of all points in the field of any moment and their relations to each other. The eyes and the retinas are nicely adapted to help us gain knowledge of the localization of objects in space as to direction. Each retina, as has previously been stated, has at least 500,000 distinct points susceptible to light at one time, from as many different directions, so that we carry around with us a visual mechanism which, at any moment of seeing, gives us at least 500,000 different directions

in that particular view. The two eyes act as one seeing mechanism in this matter of direction.

When the two eyes focus correctly the rays of light that fall upon the visual center of each retina always mean, to adults at least, the same point in space. In childhood in connection with touching objects with our hands we learned that the visual sensations received through the two eyes from the excitation of the visual centers of the retinas, which are always the clearest images, indicated one object as our hands told us. So images falling on the fovea centralis of each eye come by experience to mean the same point and direction in space. So strong is this tendency that if we look at two pictures, one with each eye, as with a stereoscope or by placing a card in front of the nose between the two eyes, we will get but one image; or if the pictures are quite different we will get alternating images in the same space. Every one is familiar with the fact that when looking through opera glasses one gets but a single image.

But, you say, most of the images in the visual field do not fall on the center of vision and yet we know the direction of all objects in the field as well as those that are most clearly seen. In this claim you are right, but it is somewhat difficult to

make clear the mechanism for this diverse direction apprehension. The fact is that for every direction point in the retina of each eye there is a point similarly placed in the retina of the other eye in relation to the point of keenest vision, and

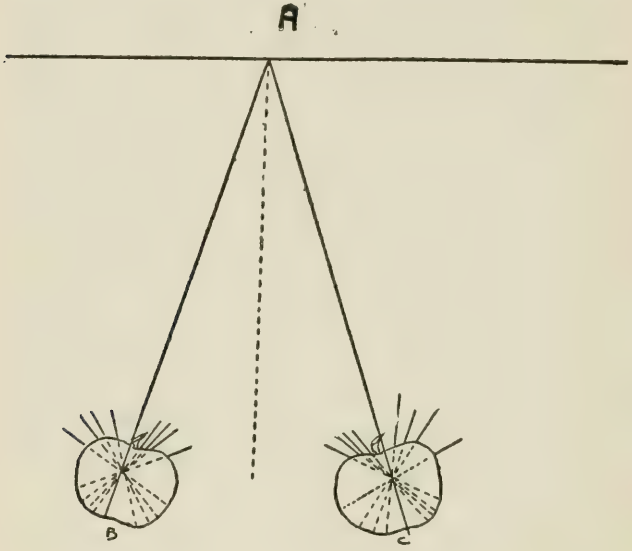


FIG. 5.

simultaneous excitation of these two retinal points means to one the same point in space. When the eyes are moved to focus clearly on some one object, all the other points on each retina are moved also but retain the same relative position to the

central point and tell us the same relative direction as before. The two eyes work together as a fine direction telling apparatus.

Perhaps this will be better understood if we take two apples (see Fig. 5) and pass two sticks which are extensible so as to lengthen or shorten indefinitely, through the center of each and attach

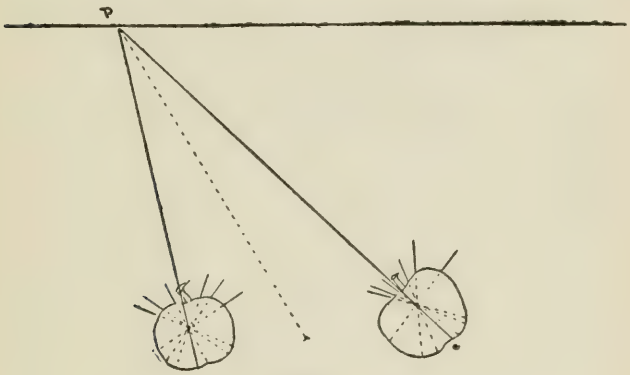


FIG. 6.

the ends of the sticks loosely together at A. Let these two sticks represent the rays of light falling from some one point in space on the fovea of each eye, which is the point of keenest vision. It can be seen that each stick ends in the same point in space, and in seeing we get but one mental image lying in the direction axis of vision AX half way between the visual centers of both eyes. Now if

we take the sticks at A and move them to another point, P (see Fig. 6), it will be seen that both apples will move a certain amount and their centers will still be directed towards A. Supposing now, that we could stick 500,000 tooth picks into the front part of each apple, running them through a center in the front part of each apple and then to the back part of each, as the rays of light from all directions pass through the optical center of the lens of each eye to a point on the retina. It will readily be seen that when we move the central sticks at point A, all the tooth picks will move at the same time and preserve the same angle with the central stick in each apple as before, and for any point in space there will be two toothpicks which would meet if extended, the visual axis of which point would have a certain angular relation to the central axis.

The eye movements which are constantly taking place give a certain direction feeling to every retinal point in each eye in reference to the central point of vision, which is always maintained, so that we are able to look at one point and at the same time have feelings of direction for 500,000 other directions.

We are undoubtedly helped in telling the direction of any object directly looked at, by the differ-

ent strains on the muscles of the eyes, as well as by the muscles of the neck. A perfectly balanced muscular strain tells us that the object is straight ahead at the level of the eyes. While a greater strain on the right hand muscles of the eyes would indicate an object to the right, and on the left hand muscles to the left, etc., the same would be true of objects above or below the level of the eyes. We become very accurate in judging the differences of direction by these differences of muscular strain. We learn to judge thus while very young, and in a subconscious manner, and are not consciously aware, without careful introspection, that these muscle strains are the basis of our idea of the direction of the central object of vision. The central point of vision in our space field at any moment is the direction center, from which all other points seen at the same time are judged as described above.

But objects not only lie in certain directions to us, but they are also of certain sizes and at certain distances away from us, and from each other. The size and distance of an object bear close relations to each other, in fact, it is largely by the apparent size that we estimate the distance away from us of anything, and a wrong estimate of size will give us a wrong idea of distance, and a wrong

idea of distance will give us a wrong estimate of size. These errors of judgment will be treated of later.

When we look at the objects around us what is it that helps us to estimate how big they are and how far away?

The eye as a visual apparatus furnishes us with much material along these lines, which we learn

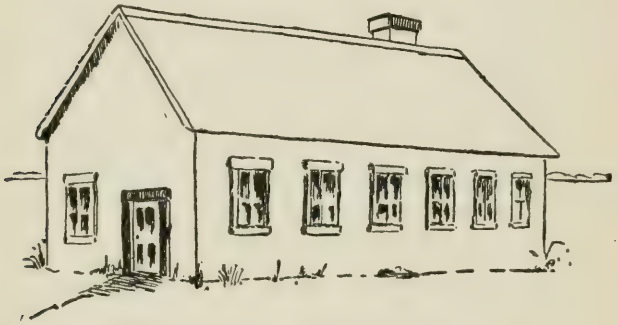


FIG. 7.

by experience to interpret. For every object with which we are at all familiar we have, we might say, stored away in our memory an image of its usual size when seen in the most common and natural way. For instance, our standard image of a human being is that of a person about ten feet away, our standard image of a watch as seen in the hand, of an automobile as passing along

the street, of a locomotive as seen from the station platform, etc.

Now what is the effect when an object appears to us smaller than the normal standard image?

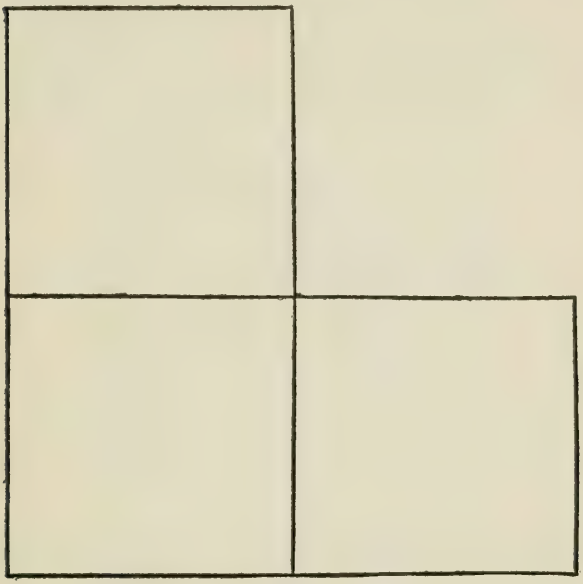


Fig. 8.

When we notice the windows along the side of a building (see Fig. 7) which are really all the same size, we see that they have a smaller and smaller apparent size as we look from the near window to the farther ones; they apparently grow smaller

and smaller the further away they are; but we are not deluded by these smaller apparent sizes, we do not even think of these objects being smaller. We see them mentally as of all the same size, we interpret their deviation from our standard image of that class of objects as indicating different distances away. We cannot even draw a cube and make it look like a cube and really draw the sides

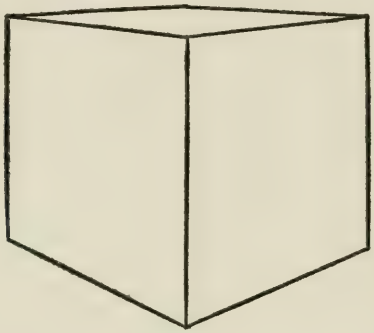


FIG. 9.

that can be seen at one time as squares (see Fig. 8). We have to make the farther edges smaller and converge the lines of the represented top and sides (see Fig. 9). If we endeavor to draw anything and make it look natural we must represent everything in the background of an apparently less size than in the foreground. We interpret things as they really are by comparison

to our standard image. We interpret the differences in apparent size as meaning differences of distance away. The house a half a mile or so away looks to us of full size (see Fig. 10), although it casts a very small image on the retina and a small coin held at arm's length would cut it off from our vision. We interpret its small ap-

FIG. 10.

parent size in reference to what it would be if close by, as meaning distance away. Mankind has judged the distance away of objects in this way from time immemorial, without a thought of retinal images or of the psychological reasons. But if the structure of the eye is considered it will easily be seen that the sizes of the images cast upon the retina are directly proportionate to the dis-

tance away of objects. The nearer an object is, the larger the image it casts upon the retina; the farther away an object is the smaller the image it casts upon the retina. These smaller or larger images are the cues for the mind in estimating the distance away of objects.

On the other hand, also, our estimation of the distance away of objects has a direct effect upon our ideas of their sizes. Filled space always appears larger than empty space, since the eye is arrested and retarded by the many objects, giving us more of a feeling of muscular activity than empty space does. Hence our judgment of the distance away of an object will be greater when many other things fill the space between us and the object in the distance; whereas when the intervening space is empty, as at sea, the judgment of distance of objects is very inaccurate and hence the estimated size is also wrong. In so far as we overjudge the distance we think any object is away the larger it will seem to us to be, and to the degree we underestimate the distance away of any object the smaller it will appear to us to be. Hence we are constantly liable to illusions in regard to the size and also the distance of objects. These illusions will be more fully treated of in a later chapter.

The second visual aid to our estimates of distance is the brightness or dimness of objects. The farther objects are away the duller and dimmer they appear, both in colors and outlines, while the nearer they are to us the brighter and clearer do they appear (see Fig. 11). These differences

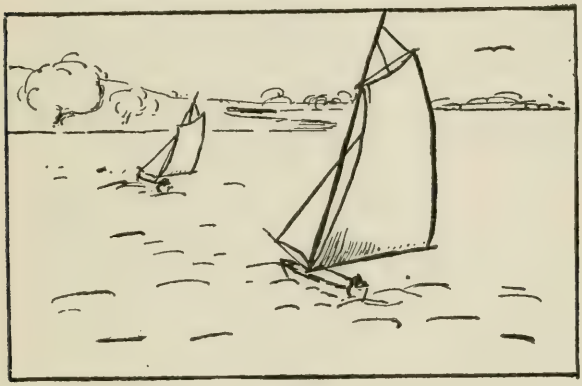


FIG. 11.

in the brightness and clearness of the appearance of objects are a great help in estimating their distances away. These different appearances of objects give rise to many illusions which will be discussed later.

The third visual aid to our perception of distance is the rapidity of motion for different objects. The faster an object appears to move

the nearer it is thought to be. This is easily noticed when viewing the landscape from a moving train. The telegraph poles seem to fly past with great rapidity, while the more distant objects have much less apparent motion. We have the illusion here that the objects are moving

FIG. 12.

past us because we are more used to successive images caused by objects moving past us than caused by our movement past objects, and we have no sensation of the movement of the train save sensations of jar. We learn by experience that

the apparently fast moving object is near, while the apparently slow moving object, although it may be really moving as rapidly as the apparently faster, is farther away. When we see an automobile on the distant road, apparently barely moving and yet really going thirty miles an hour, we think it is far away (see Fig. 12), or when we

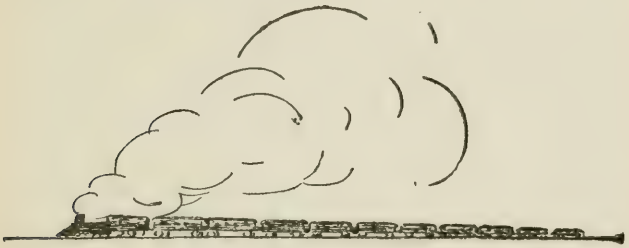


FIG. 13.

get an image of a train from several miles, across the valley, which seems hardly to move and yet we know it is the "Limited" going sixty miles an hour (see Fig. 13), we cannot help but realize that it is miles away, since the apparent speed is so slow.

But there are sensations, beside the purely visual sensations, which are of help in estimating distance. We have spoken heretofore of the accommodation strains from the lens of each eye and the muscular strains we get from the conver-

gence of the two eyes. As an object draws nearer these strains increase and as it moves away these strains grow less. These strains are indeed always proportionate to the distance away of the object of vision. When, however, the object is farther away than a few hundred feet or so these strains are not very pronounced, for we practically look at all objects beyond a certain distance away, with the axis of the eyes nearly parallel and with slight lens accommodation. But for objects near us we get for each different distance a combined muscular feeling from convergence and accommodation of the eyes, which becomes associated with the apparent size and brightness and dimness of objects and gives an accurate basis for the different distances. For far away objects we rely on apparent size and brightness of objects for our estimation of distance.

There is yet another element to be considered before our explanation of distance judging is complete. The final estimation of distance rests upon the muscular strains from reaching, creeping, or walking. It is doubtful if a child, who was from birth completely paralyzed so that he never moved anything but his eyes, could ever judge distance. He would have no basis for knowing that apparent size and brightness of objects, conver-

gence strains and accommodation strains of the eyes meant different distances away. He would think the apparent differences in sizes of objects to be real differences and the brightness or the dimness to be simply different color qualities of objects. There is a strong tendency from the first, when the child sees objects to reach for them. We get ideas of distances from these reachings associated with apparent size and eye strains. The young child, however, has little idea of distances outside of his reach; he will try to grasp the moon or any far away object. As soon as he begins to creep he soon associates the feeling of the distance crept to an object, with the apparent size and brightness and eye strains which he has when at the starting point. When he begins to walk he then associates the sensations of muscular strains necessary to walk from one object to another, with the visual and muscular sensations from the eyes which he had at the starting point. So it can readily be seen what a large part our muscular movements play in our ideas of distance. With every different apparent size and brightness or dimness of objects, and with every different convergence or accommodation strain from the eyes, we get associated inseparably the muscular sensation necessary to reach or walk to the object, and

these strain sensations are the ultimate bases for our distance judgments.

The factors that give us ideas of distances may be put into the form of an equation:

Distance = [(Apparent size + Brightness + Rapidity of motion) visual elements + (Convergence strains + Accommodation strains) eye muscular sensations] + [Muscular sensations of reaching or walking.]

We have little idea of distances farther than we have walked, unless, perhaps, we can combine our idea of a mile into an idea of ten, or our idea of ten miles into a hundred or a thousand. It is, however, very doubtful if we can mentally combine our recollection of the muscular exertion for one or ten miles into a unified feeling of a hundred or a thousand miles.

How far is it from New York to Chicago? If we have never traveled it or some similar distance our idea is very vague; it is only a few inches on our mental map. If we had walked the distance it would seem to us at least forty or fifty times farther than by train. Any distance is long or short depending upon the muscular exertion required to cover it. A mile over a rough and muddy road will seem like ten miles over a boulevard. In old Colonial days it was as far from

New York to Boston as it is now from New York to Denver. When in the future we travel in aeroplanes at 200 miles an hour, distances will only be about a fourth of what they are now. The world is constantly shrinking; it was eighty days around the world for Jules Verne; it is only half as much now. We think nothing of taking a train at New York for San Francisco, but if we thought of walking it the distance would seem appalling. The distance from New York to Liverpool is now only four or five days, but to the Pilgrim fathers the distance across the Atlantic must have seemed incalculable. When it comes to feeling the distances from us of the sun, moon and stars the mind falters — it cannot in any way comprehend such immense distances, and this is one cause of the many illusions that we have in regard to the size of the sun or of the moon.

The reader by this time may be weary and ready to take up the latest novel, and let the world and its objects take care of themselves. He may feel that he is not at all aware of all this complicated mechanism and material for judging the sizes and distances of things — he just looks and knows. That is true,— he does just look and know where and what objects are and how far away and how big, but only because of a long

experience and a wonderfully complicated set of associations. The mind has a grand power of synthesizing or fusing unnoticed, mental processes into useful and unified mental products, and in no case is this more true than in regard to the power of seeing the world in space.

There is another interesting problem in regard to visual space perception that should be considered; that is, how do we learn to tell through sight that objects are solid, that they have a third dimension? One's first perceptions of solidity are undoubtedly gained by grasping objects, which give us sensations both in the fingers and the palms of the hands, but we soon learn through sight to judge solids without touching them. One theory is that when looking at a solid object, unless one plane side only of it is looked at, the different points of the object are at different distances away from the eyes, and hence cause different convergence and accommodation strains. These, we learn to know, mean third dimension or solidity. This explanation, however, would only apply to the judgment of near objects. Beyond a relatively small distance away these strains would be inappreciable.

Another interesting theory is that of stereoscopic vision or retinal rivalry. We mentioned

in the first part of the chapter the fact that the images cast upon the centers of vision of the two eyes always tend to fuse into one, and even if there is an entirely different image cast on each eye they will seem to alternate in the same place in space. Now when we look at the corner of a solid object it is evident that we see more of the right hand part of the object with the right eye and more of the left-hand part with the left eye. The images cast upon the fovea of each eye are somewhat different, and create a measure of retinal rivalry. These differences, we learn to know, mean solidity. We combine the two images into one solid object in space.

Every one is familiar with the beautiful effect of solidity and depth that the stereoscopic picture gives. The two stereoscopic pictures look alike, but they are not quite so. They are taken from slightly different positions, and thus give enough retinal rivalry, when looked at side by side by the two eyes, to give us the perception of solidity. The stereoscope is a convenient arrangement to enable one to look at the two pictures with the eyes in a normal position of convergence, but if one can look at the two pictures with eyes parallel, as if looking far away, he can fuse the two pictures and get the stereoscopic effect without the

stereoscope. If the reader will hold the edge of a card perpendicularly against his nose and forehead, so that he sees one side of the card with the left eye and one side with the right, he will be surprised to find that the card appears as a wedge, with the larger edge away from him (see Fig. 14).

FIG. 14.

These two theories are satisfactory only for comparatively nearby objects. For all distant objects we evidently learn to judge solidity by the lights and shadows, and by the relations of one object to another.

There is one question that may yet remain in the mind of the reader; that is, how is it that we see things right side up when the images on the retinas are always upside down? This question implies a wrong idea of the action of the mind in knowing the retinal images. The images are not carried to the brain. Only optic nerve fiber currents are carried to the brain, where the terminal brain cells are stimulated to action. The mind interprets the sensations caused by these brain cell vibrations as meaning color or light from some certain space direction, and the mind in a wonderful way has a perception of an object in space by the effect of the many visual brain cell excitations at that time. These sensations mean light from a

certain direction in reference to the axis or central point of vision at the time. We are not mentally aware that the retinal image is inverted. Men saw things right side up ages before they knew of the inversion of the retinal images. All points on the retina below the center of vision have come by association to mean light from above, and all points above the center of vision have come to mean light from below. It makes no difference to us then that the retinal images are inverted since all points on the retina have an inseparably associated direction meaning, and the sensations from the brain cell excitements are only the symbols or occasions that the mind interprets as light from certain directions in space. If the images themselves were transferred to a screen in the brain there would needs be another eye to see them and another brain for the eye, and so on, ad infinitum, and we would never get where we could see.

CHAPTER V

BINOCULAR AND MONOCULAR VISION COMPARED

NATURE has been kind to us in regard to our visual apparatus; she has given us two eyes. This may seem like an unnecessary duplication and the reader may wonder if one would not be just as well off, and see just as well, with one Cyclopean eye in the middle of the forehead. Even if there were no visual advantage in two eyes it certainly is a great assurance against blindness to have two eyes, for thousands of people have lost one eye and yet get along remarkably well with the other. From the experiences of one-eyed people we learn a great deal that enables us to judge what visual advantage two eyes are, and also how one eye can learn to do practically what two eyes can do. In writing on the subject of this chapter the author is not speaking from hearsay or the evidence of others, but from his own knowledge and experience, having lost the sight of his left eye thirteen years ago,

and hence has had a long enough experience to know what unchanging monocular vision is.

A person can judge direction as well with one eye as with two, but does not have as many direction points in his visual field, because the nose cuts off about 45° of the visual field. This is often a source of annoyance, because if one forgets this lessening of the visual field he is likely to run into something or fail to see something on the nasal side which with two eyes would have been noticed. One real advantage of having two eyes, then, is a larger visual field and a sensitivity to light from about one-fourth more directions. If a person who is used to seeing with two normal eyes closes one eye his estimation of the distance of near objects will be somewhat unreliable. If the reader will tie a finger ring to a string and have some one hold it about three feet in front of his face, then close one eye and try to put a pencil through the ring when it hangs at right angles to himself, he will find that he is very likely to miss the ring entirely, while if he will open the closed eye he will find that he can put the pencil through the ring almost without failure. With only one eye the muscular strains of convergence are of course lacking and only the accommodation strains from the one eye are afforded as the basis for judging

the distance of near objects. But it is remarkable how a person restricted to the use of one eye learns to judge the distance of objects, both near and far, with a very great degree of accuracy by the relation of different objects and a purely mental judgment. However, such a person is somewhat more liable to illusions of size and distance than a person who has two eyes.

Theoretically, the judgment of solidity, which is supposed to be based, for near objects at least, upon the different images from a solid object and upon points on the solid object at different distances should be very much less easy to a one-eyed person. Most writers on the subject of monocular vision claim that the world looks peculiarly flat and lacking in depth to monocular vision, but they are mistaking the way the world looks to them when looking with one eye, to which they are not accustomed and the way it looks to one who for years has looked constantly with but one eye, and they leave entirely out of account the wonderful power the mind has through its past experiences of making good the deficiencies of the sense organs. The fact is that when a person loses one eye in adult life, he very soon learns to see the world with depth and solidity just as he did with two eyes, and there is positively no men-

tal feeling of flatness or lack of the third dimension. What effect the loss of one eye would have upon a small child in respect to his learning to judge solidity the writer can offer no experimental proof of, but he believes that it would hamper the child in learning to judge the objects around him, for the child has no background of experience in judging the world, which accumulated experience is of great help to the adult.

All the beauties of color, light, shade, and form, are just as evident to monocular vision as to binocular. Hence, for practical purposes, monocular vision, after several years' experience, is as good as binocular, with the exception of slight inaccuracies in judging distance and size of near objects, and the fact that the visual field is less wide. If the two eyes do not focus correctly and constantly give double images, one is better off with one good eye, for to monocular vision there can never be any double images. With two eyes, if light from any object falls on two retinal points which are not similarly placed in regard to the center of vision in each eye, the mind sees two images and not one single image.

If the reader will hold up his forefinger of one hand about two feet in front of his eyes and focus his eyes upon it, and then hold up the forefinger

of his other hand between the far finger and himself but still look at the far finger, he will get a double or confused image of the near finger. If now he looks at the near finger he will get a double image of the far finger. In these cases of double images the light from the one object falls on symmetrical points on the retinas of the eyes, and not on similar points. These symmetrical points do not mean to us light from one direction; they are not used to working together, hence the double images.

Push against the side of one eye, throwing it out of focus with the other, and the whole world looks confused or doubled. People, whose eyes are permanently out of line with each other, see the world always in this double or confused manner, and unless the deficiency can be corrected by glasses they have to learn to ignore one image. Such people practically look with one eye at a time.

Nature has been kind to us in regard to the brain connections of the eyes. The optic nerve fibers from the right side of the retinas of both eyes run to the right side of the brain, ending in the brain cells of the right occipital lobe, while the optic nerve fibers from the left side of the retinas of both eyes run to the left occipital lobe; hence

only the fibers on the nasal sides of the eyes cross.

It will readily be seen, therefore, that a person with only one eye uses both sides of his brain in seeing, just as a person with two eyes does. This obviates the excessive work the brain cells would have to do if all the excitations of the retina of one eye went to one side of the brain, so that a one-eyed person could only use one side of the brain in seeing.

The person having only the right eye gets the excitation from the left visual field with the right occipital lobe, and the excitation of the right visual field with the left occipital lobe. The opposite is true of one with only the left eye, yet the mind in a wonderful way combines these excitations of the two sides of the brain into one visual field.

In looking with two eyes, if the eyes are mechanically correct in their workings, the mind will combine the images from the two eyes into one visual field without confusion or doubleness of images, although sometimes it will misinterpret the images.

The peculiar crossing of the optic nerve fibers described above, is given by some writers as a physiological reason, at least, why we do not see objects double, the images from which fall on the

same side of the retina of each eye, for in such cases the excitation goes to one side of the brain. This reason, however, is somewhat negated by the fact that the fovea, or center of vision, of the right eye is connected with the right side of the brain, and the fovea of the left eye is connected with the left side of the brain, and images falling on these two spots of the retina, if the eyes are in focus, are of all others most likely to be seen as one, showing again what a combining and fusing power the mind has.

CHAPTER VI

VISUAL ILLUSIONS AND HALLUCINATIONS

THE eyes transform the stimulations of light from the outer world into excitations of the visual brain cells; the mental effects of these excitations are the visual sensations. The mind must learn to interpret these sensations as coming from and indicating objects or activities in the outer world. This is that mental activity which is called perception. Sensations are always ascribed meaning, in terms of past experience, and hence each one's past influences what he sees or how he sees. Each person might think of himself as looking at a passing panorama of objects. As they pass before him in an endless succession he must instantly name or label each one. When he labels an object correctly we call that perception; when he labels an object wrongly we call that an illusion. However, as has been remarked in the preceding chapter, sometimes the eyes themselves are at fault and give us a wrong sensation from the outer world, as in cases of incorrect focusing or of

certain effects of muscular strain, to be discussed later. These illusions, where the eyes are at fault, fooling the mind as it were, are called primary illusions. Where the illusions are wholly mental and due to the mind's misinterpreting the visual images, they are called secondary illusions. Every one is subject to a surprising number of both of these kinds of illusions, many of which we are never aware that we have, and many, even after we know we have them, that can never be corrected or overcome. These latter are mostly cases of primary illusions.

When one has a true perception of an object further investigation only confirms the original impression, while, where the original impression was an illusion, patient investigation will generally reveal the incorrectness of our idea even if we cannot overcome the illusion. If the eyes act so as to give double images one can learn that there is only one object by touch, even if the doubled image cannot be overcome; but if one sees a white tombstone as a ghost, a second glance will reveal only a tombstone.

It is important for our safety and welfare that we interpret correctly the sensations that we get from objects. We need to judge correctly what objects are and where they are, and of what size

and distance. To see a rattlesnake as a garland of flowers, to underestimate the distance away of an object to which we are trying to walk or swim, to think that the glittering sand far across the desert is a lake, might be fatal.

On the other hand, it would be a dull and prosaic world from which all illusions were vanished and only the actual material side of objects seen. The beautiful marble statue is but so many pounds of calcium carbonate, and yet the seeing mind finds indescribable beauty there. The greatest painting in the world is materially only so many daubs of paint on a piece of canvas, and yet men put a priceless value upon it for what they see in it. Our most beloved friends are only so many pounds of muscle, bone, and fat, etc., and yet we see in them all the mystery of character and loveliness. Nature itself, is but so many trees, rocks, rivers and mountains, purely material objects, and yet we see the very spirit of God Himself in Nature. In all these cases the mind goes beyond the merely sensory and adds an interpretation which, strictly speaking, could be called more or less illusory.

Perhaps it would be interesting to note some illusions which are very common, where our eyes fool us by the sensations they give us. The illu-

sions of doubleness we sometimes have, have already been mentioned, but we have many illusions from the eye muscular strains which occur constantly and with perfectly normal eyes. For example, we overestimate filled space and underestimate empty space. The varied objects between us and a distant hill make the hill seem much farther away than as though we looked across the water. A harbor filled with ships appears much larger than the same harbor when empty. A room well finished and furnished seems bigger than when empty. On the other hand, when we look directly across from one hill to another, without noticing the valley between, the distance seems much shorter than when looking from farther down where the landscape carries the eye. The landsman looking out to sea at the fishing boats will estimate them to be one-half a mile away, when really they are five or six miles away. We

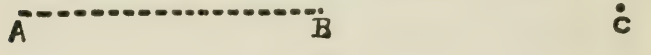


FIG. 15.

all have observed how near the moon looks at the zenith and how much larger it looks on the horizon where there are many intervening objects between ourselves and the moon. For a simple illustration of this form of illusion see Fig.

15. Point B is the same distance from A that C is from B, and yet A and B probably appear to the reader as farther apart,

Another interesting case of this form of illusion is seen in Fig. 16.

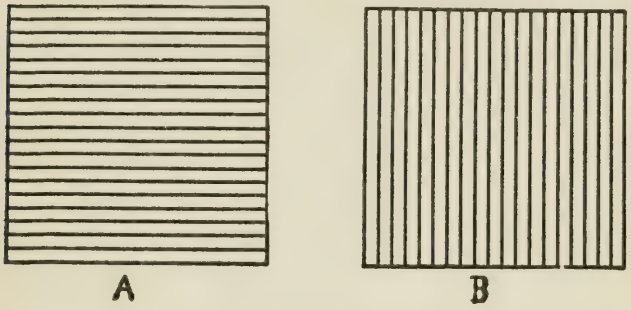


FIG. 16.

A and B are squares of exactly the same size. Square A, which has the lines across it drawn horizontally, appears taller and slimmer than square B, which has the lines drawn perpendicularly. Square B looks shorter and broader than A. Any object with lines drawn horizontally across or around it will look taller and slimmer than where the lines run perpendicularly. This illusion sometimes is present in our estimates of the height and the breadth of people because of the arrangement of the stripes of their wearing apparel. Has

the reader ever noticed how tall a convict looks in his horizontally striped prison garb?

A dress or skirt made of goods with regular stripes of equal width running round and round will make a woman look taller, while a dress with regular stripes of equal width running up and down will make her look broader than usual.

The new style of skirts with vivid perpendicular stripes, now being worn make the young women look broader than usual while the many flounced skirts of past seasons made them look taller and slimmer.

If, however, there are only a few very broad and pronounced stripes, bands, or lines on a skirt or if some of the stripes are much broader than the others they will attract the attention and cause illusions in our estimates exactly the opposite of the above. The pronounced perpendicular lines causing an illusion of greater height and the pronounced horizontal lines causing an illusion of greater breadth than usual.

The probable explanation of the class of illusions shown in Figure 16 is that the eyes are arrested by the intervening or space-filling objects or lines, and give us, therefore, more sensations of muscular movement when traversing filled space and lead us to conclude that the space is bigger, or

that the distance is greater, because of more and bigger feelings of eye muscular exertion. These are primary illusions and difficult to overcome.

Perpendicular objects or distances always seem longer than the same distances or objects would appear if seen on the level. One hundred feet

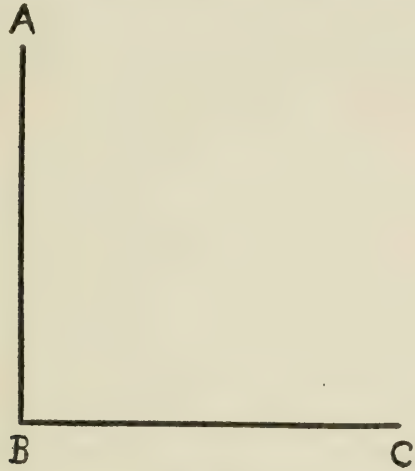


FIG. 17.

perpendicularly, looks much greater than one hundred feet on the ground. This is illustrated in Fig. 17.

The perpendicular line AB is the same length as the horizontal line BC, but it looks longer. Let the reader try to draw a figure without a rule, that looks like a square, and he will be surprised

to find that it is not high enough to be a square. If, however, he uses a rule and draws a real square it will look too tall. All perpendicular objects and distances are then overestimated as to their height. These illusions are also primary illusions, and persist in spite of our knowledge of their cause. They are probably due to the fact that there is more muscular strain in moving the eyes up than sideways.

FIG. 18.

Another primary illusion of somewhat the same nature may be noticed by looking at Fig. 18. The reader would probably be willing to wager an ice cream soda at least, that the horizontal line CD is longer than the horizontal line AB. But if he will measure these lines he will be surprised to find that they are exactly the same length. But even the knowledge that they are exactly equal in length will not enable him to overcome the illusion as to their difference in length. This is because this is another case where the sensations from the eye movements fool us. In moving our eyes from A to B and from B to A, to estimate the

length of the line AB, we are involuntarily checked and hindered in the eye movements by the oblique lines inwardly directed at A and B, hence our estimate of the length of line AB is too small. On the other hand, when we run our eyes back and forth from C to D and D to C, we overrun the ends of the line CD, because of the oblique outwardly extending lines from C and D, which muscular overrunning causes an overestimating of the length of the line CD.

These illustrations of primary illusions might be extended indefinitely, but enough have been given to show that our eyes are not always to be trusted and that the evidence of the senses is not in all cases conclusive, and that even knowledge of the cause of the illusion will not overcome it, if it is a primary illusion caused by the mind being fooled by the sense organ.

All people are about equally susceptible to primary illusions. Even the most learned psychologist is just as subject to them as the person who has never investigated the subject. But when we come to investigate secondary illusions we will find that they differ with different people, since they depend upon the mental interpretation of the sensations from objects. These interpretations depend altogether upon the past experience and

mental habits of each person, hence of course, differ with each person. No two people probably ever saw the same thing just alike. Each may get the same visual sensations but each interprets it differently and sees a different object, to a degree. So in a certain sense, all perception is somewhat illusory, but the trained observer along any line is far more correct in his perception than the untrained and inexpert observer.

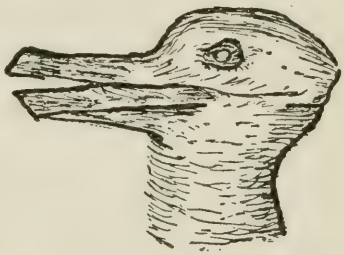


FIG. 19.

Each person sees what he is in the habit of seeing or what he is expecting to see, and hence it follows that every one is at times deceived in his visual perceptions. What does Fig. 19 look like to the reader? A duck or a rabbit? Let the reader close his eyes a moment and imagine either a duck or a rabbit, then suddenly open his eyes and he will probably see what he imagined. This little experiment shows how careful we should be

about harboring prejudices against any object, place, or person.

There are many illusions which are mixed primary and secondary illusions. One very common illusion, which has been mentioned, is that of seeing the moon at the horizon as much larger than when seen at the zenith. This is an illusion of size and distance, as was mentioned in Chapter IV. Any overestimation or underestimation of the size of an object will affect the judgment of its distance, and any overestimation or underestimation of the distance of an object will affect the judgment of its size. When the moon is at the zenith, there being no objects intervening to carry the eye or to compare the moon with, we underestimate its distance away, and hence, although it casts the same image on the retina that it does at the horizon, we think it much smaller than at the horizon. When, however, we see the moon at the horizon, the many intervening objects make us think it is much farther away than at the zenith, and therefore we see it as much bigger as we think it is farther away. This illusion can be dispelled by rolling a paper tube and looking through it at the moon on the horizon. All intervening and surrounding objects being cut off from our view, the moon will come down to a ten cent piece in appar-

ent size. The above cases of the moon are typical illusions due to wrong estimation of distance. This wrong estimate is a primary illusion, explained by the lack of eye muscular feeling in looking through empty space and hence underestimation of the distance, or greater muscular exertion in looking through filled space and hence overestimation of the distance. The wrong estimate of the distance of an object, however, affects our

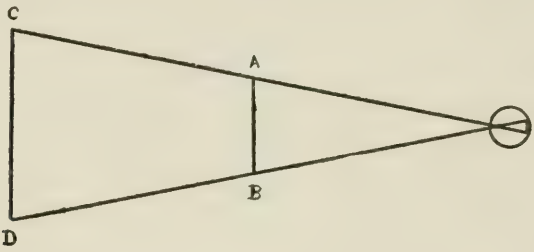


FIG. 20.

judgment of the size of the object, and this is a secondary illusion, an illusion due to a wrong judgment.

The reader may be helped in understanding these illusions if he will carefully study Fig. 20, which for simplicity is diagrammed for only one eye. Suppose that CD be an object, a house for instance, on a Colorado mountain side, seen across the valley from another mountain side. Owing to

the clear air of that climate, which makes the house look very distinct, and to the lack of intervening objects, the distance away of CD is generally underestimated, hence it is thought to be at AB. Now it will be readily seen that if CD were at AB, as we think it is, it would have to be as small as AB to still cast the same image on the retina as it does where it is. It is really, however, at CD and casts the same image on the retina as if it were reduced to the size and distance of AB, therefore it appears to be at AB. Vice versa, if we think an object AB to be at CD, on account of the hazy atmosphere and intervening objects, as the moon at the horizon, since AB casts the same sized image on the retina as it would if at the distance and of the size of CD, we see AB as large as if it were at CD. As much nearer a thing is thought to be than it really is, the smaller it appears, and as much farther away a thing seems to be than it really is, the larger it seems to be. The reverse would be true of wrong estimates of the sizes of objects in their effects on judgments of distance. If the size of an object is underestimated, its distance, if we were compelled to judge solely by the apparent size, would be overestimated, and on the contrary, if the size of an object is overestimated, the distance, if we

judged it as before — solely by the apparent size, would be underestimated..

To sum up distance and size illusions. Objects judged farther away than they are look bigger than they are. Objects judged nearer than they are, look smaller than they are. On the other hand, objects judged smaller than they are look farther away than they are, and objects judged bigger than they are look nearer than they are.

The illusions caused by wrong estimate of distance as to near objects are more common to monocular than to binocular vision. The author looked out of his back door one day and was much perturbed by seeing what appeared to be a striped yellow tiger crawling along the top of a fence some distance away. A second glance showed that it was a striped yellow cat crawling along the top of a fence between himself and the farther fence where the cat first appeared to be. Overestimation of distance caused an overestimation of size. With two eyes the convergence strains help estimating distance more correctly than is possible for one eye, where convergence strains are lacking. But for more distant fields, where convergence strains are slight, people looking with two eyes are just as likely to have these illusions as those looking with one eye. The reader will,

it is hoped, realize that learning properly to estimate size and distance is a difficult process and will not wonder that the child is so lacking in these regards, and will also realize that even the best observers may be deceived by conditions of which they are unaware. Any one is foolish to risk his life upon his unaided estimate of size and distance.

To return to pure unmixed secondary illusions, where the eyes are not to blame, since they give us a true image of the object and correct muscular strains, but a wrong interpretation is put thereon. These wrong judgments are exceedingly common. A person's own child looks beautiful to him; one's own friends appear differently from strangers; the home of one's childhood always seems charming. New York is the only city on earth truly worth looking at — to the New Yorker, while Boston has all the appearance of the celestial city to the Bostonian, who was born and brought up in the Back Bay, and never wandered to the north, east, or south sides of the city. The Federal soldiers looked like fierce devils to the Southern people during the Civil War, and to the warring peoples of Europe at the present time, their enemies look the incarnation of all that is hateful. How often we see a tall figure standing in a dark room, which

turns out to be only a coat on its hanger! Or we see a footpad waiting for us behind the next tree — which turns out to be but a shadow cast by the electric light up the street! All such illusions are mere errors of judgment and can be dispelled by a spirit of investigation, accurate observation, and wide experience. Many illusions are better not dispelled, as remarked farther back, but many immediate sensory illusions must for our safety and welfare be overcome.

There are some illusions that are hard to classify as either primary or secondary. Almost any person has in his eyes what are called floating specks. These are seen as in space, and when looking at a wall some distance away a floating speck in the vitreous humor may look like a face or a figure on the wall. After images may also be seen as colored figures at some distance away. Many ghosts that are seen are probably cases of these types.

Dreams are often illusions, but as dreams rarely lead to motor activity these illusions are harmless. When the heart beats too rapidly in sleep, due to indigestion or heart disease, one may have a horrible vision; his heart is beating as though he has seen something terrible, so the mind sees the terrible something.

Any sort of a sensory stimulation during sleep affecting the touch, hearing, smell, or even taste, may possibly cause dream pictures to one who is of the visual type of mind. The ears are always open, as is the nose, during sleep, and the touch end organs are always ready to act, both in darkness and light. But when one sleeps the eyes are covered by the eyelids, and there is little or no sensation that can come through the eyes during sleep as basis for visual illusions. Most of the visions, therefore, in dreams, are of a purely hallucinatory nature, and are more properly discussed under hallucinations, to which we must now proceed.

It was stated above that illusions are misinterpreted sensations, and always involve some external stimulation of the senses, however slight. There is always some real objective basis for an illusion. Hallucinations, however, are always of purely central or mental origin, due to some image conjured up by the brain cells themselves, without any immediate sensory stimulus. Ordinarily we are not deceived by the images of memory or imagination. They are so much weaker and fainter than reality that we know at once that they are purely subjective and inward. There is a tendency, however, to project or to see all mental

images as in space outside of us. All of our memories and imaginations are revivals of former experiences of objects, so that when purely mental images are clear and intense we tend to take them to mean external objects. Indeed the only way we know an image of a real, present object from an hallucination, is by the superior clearness and persistence of the real image. We are often aware of what might be called *false* hallucinations when a figure is seen in space, but we know that it is a purely subjective picture; but we cannot tell how many *true* hallucinations we have had for a true hallucination appears at the time like a real perception and we may never become aware that our visual experience was not real.

In dreams personal judgment and reason are weak. In that dim twilight consciousness there are no real visual images with which to compare the dream images, so hallucinations have full play. If the dreamer is healthy the brain cells that he used during the day will be recuperating during the night, and he will not dream of the present or of his workaday life. He will dream of far off scenes and distant lands, and times of long ago — often of the halcyon days of childhood. The brain cells that were long ago impressed, having been unused for a long time dur-

ing waking life, are full of energy and throw into the dream consciousness these images of long past impressions. These images are vivid and bright, and not having to stand comparison with reality, seem to be real to the dreamer. If a person, however, is overworking his brain and unduly exciting his brain cells, this excessive stimulation may continue at night, and he dreams of his work, and his visions are all of the day before. The feverish and excited state of these brain cells makes these images seem real. This is a serious condition and gives warning of impending brain and nervous breakdown.

In delirium of fever or disease, the brain cells are pathologically excited and all kinds of strange things may be seen. Since these images are very clear and intense, the patient thinks they are of real objects, and he cries with terror and cowers and trembles at the horrid shapes and figures he sees all around him. If this condition of certain brain cells becomes chronic, due to brain lesion or congestion, these images persist and become permanent delusions, haunting the person wherever he goes. Then we have insanity. Macbeth is a classic example of a persistent hallucination, for wherever he went the pale, accusing face of Banquo seemed to follow him.

The sensory type of hallucinations which different people have depends upon what the predominating mental images are that they have, but as the larger proportion of people are of the visual type of mind, as will be shown in the next chapter, the majority of hallucinations are of a visual nature. More people see ghosts than hear them, or feel their clammy touch. The writer, being strongly of a motor type of mind, cannot speak from his own experience as to visual hallucinations. He has often felt touches and heard sounds and voices of an hallucinatory nature, but he has no recollection of ever having had a visual hallucination. What, therefore, is said here about waking hallucinations is from the testimony of others.

Hallucinations often occur to sound and sane persons, even when they are awake. So strong is the visualizing power of some persons that they can see anything in space as real as life, that they want to see. A former student of the writer claimed that she could, at will, see any one she wished, seated in a chair before her. She could produce visual hallucinations at will. This is a dangerous power, for when the day comes when such a person can no longer distinguish hallucinations from images of reality, insanity is near. In

most cases, however, waking hallucinations are involuntary and unsought and not known at the time, perhaps, as hallucinations to the experiencer. They indicate some temporary excitement of certain brain cells and are not necessarily of serious import. They are often induced by excessive apprehension or expectation, as in the case of a haunted house where a ghost is said to walk at midnight on a certain eve. In such a case, many people will see the ghost as it has been described to them. No photograph, however, has ever been obtained of such a ghost; it will never pose for a picture. When one thinks he sees a ghost or a discarnate spirit, let him close his eyes and if he still sees it he doesn't need to worry, it is all in his mind. If however, it disappears from his senses when he closes his eyes, he had better get a brick or a club and test the ghost's reality.

As a rule, waking hallucinations in the healthy individual are simply markedly clear images reproduced from the person's own past, and without any immediate external cause. But from the writings of Podmore, Gurney, Hodgson, Hyslop, Sir Oliver Lodge, and a host of others, who have made thorough researches on hallucinations, hypnotism and mediumship, we *might* be led to grant the possibility of hallucinations being suggested to

the mind of one person by the mind of another living person, or by the discarnate spirit of some deceased person, without any stimulation of the sense organs.

It is thought that hallucinations may be induced in a hypnotized subject by mere suggestion. The claim is made by some writers that the suggestion may be telepathically communicated from one person to another, from a distance, the hypnotic state being thought to be more favorable to telepathy. Telepathy is where one mind influences another to some image or thought without any sensory stimulation or connection between the two. This is contrary to the very thesis of modern psychology which is that nothing from the outside can enter the mind except through the senses. Hence telepathy cannot be accepted without overwhelming evidence. Many cases are given in the records of the Psychical Research Society of *so-called* induced hallucinations, where one person willed strongly to appear to some other person and at that moment, was seen by the other person as a real figure in space; or one person thought a great deal about an absent friend and was moved to write a letter, and was surprised in a few days to receive a letter from that friend written on the same day that he wrote; or the dying person, at

the moment of dissolution, was seen by a near friend who was far away.

Of course there is always an element of doubt in all these cases, as to the accuracy of the observations and facts. To estimate whether the hallucinations occurred at the exact moment of the distant cause is difficult, as watches do not all agree to the second, and people may not think at the time to look at a watch. Again, we are constantly having dreams, hallucinations and thoughts about distant friends, and mere accidental coincidence may be the explanation, there being no causal connection between the two separated minds at all. A great number of cases, accurately reported, must be figured by the law of chance, to decide whether such cases of contemporaneous hallucinations are more frequent than the law of chance would allow. Men are prone to notice striking coincidences and to ignore the thousands of cases where no telepathic hallucinations occur even under conditions of extreme suffering and sorrow on the part of the beloved person. How many millions of men have lain suffering and dying on the battlefields of Europe within the last three years, calling in their delirium for wife, mother or sweetheart, and yet these faraway beloved ones have had no hallucina-

tory images of any kind of them in that extremity. We will probably have a great number of stories after this war is over, about how a wife, mother, or sweetheart saw her loved one lying bleeding and dying on the field of death, at the very time it took place, but all people are likely to have such hallucinations from worry and anxiety, and probably as many such hallucinations occur where the persons seen wounded and dying were not at all hurt, as where they were wounded or dying.

We are inclined to consider the hallucinations coincidental with the facts as telepathically induced, while where no coincidence existed between hallucination and fact we admit the hallucination was purely individual. It may be that strong vibrations of the visual or other brain cells in one person may cause similar vibrations in the same class of brain cells in another person closely attuned to the first by ties of blood or affection, even when so far apart that no sensory effect is possible. If the more grossly material wireless telegraphic instrument can affect another instrument with which it is attuned, even if thousands of miles away, without a wire connection, may not the delicate instrument called the brain be also affected by vibrations through space from another brain with which it is attuned? Or if discarnate spirits ex-

ist may they not send out vibrations that might affect the delicate brain cells of a living friend and induce hallucinations or phantasms in his mind? Abstractedly speaking, perhaps they may, but a mere possibility does not establish a fact or law. These are most vital and profoundly interesting questions, upon which great scientists are working and conclusive answers to which we must await with open mind.

This, however, is true, that no human mind can conceive or be aware of any idea except in some sensory terms. The mind can only know what is in some form of a mental image. If God Himself should communicate to a human mind He must do it in the form of sensory images, either by some direct excitement of the brain or through some external exciting object. The revelation must always be a vision seen, a voice heard, or some form of sense imagery. So, if telepathic communications are true, even then it holds that the mind cannot be aware of anything unless the communication is presented to the mind as a sensory image or hallucination. Moses *saw* the burning bush, St. Stephen *saw* the heavens open, St. John on the Isle of Patmos *saw* the Celestial City, St. Paul *saw* a blinding flash of light and *heard* a voice speaking unto him as he

was on the road to Damascus. Seers and prophets have seen visions and dreamed dreams in all ages. Whatever causes these dreams or visions it is evident that they always have to be in sensory form in the mind of the experiencer.

CHAPTER VII

THE VISUAL TYPE OF MIND

As we remarked at the end of the last chapter whenever any one dreams, remembers, imagines, or thinks, he must make use of mental images of some kind or another. There are great differences between different people as to the predominating type of mental images which they use. Some people are ear minded and remember mostly in auditory terms. Some are motor or tactile minded and remember best in terms of movement and touch; while some are eye minded and remember best in visual terms.

The larger number of people are seemingly of the visual type of mind. They either have relatively better vision than any other sense, or else their training has conduced more to learning through sight than through touch or hearing. The strong visualizer cannot imagine how those who have few or no visual memories or imaginations can have any mental content at all. They cannot understand how another person can recall

a verse or a rule and not have come into his mind visual images of the words. When the visualizer recalls or imagines he sees the word or the object recalled in the form of a visual picture. He is perhaps unaware of the extent to which sound images or motor or tactile images constitute the imagery of the auditory or the motor type of mind. The visual type of mind learns and remembers best what it sees, and even when impressions are made through the other senses they are translated into visual images and so remembered and recalled. There are various estimates as to the percentage of people who are of the visual type, but real evidence on this point is scarce and the estimates not very trustworthy. However, all investigators agree that there are more people of the visual type of mind than of any other type, and that this is especially true of women and girls. This shows to what a supremacy in the sensory realm vision has attained. To the larger number of people "seeing is believing" and the other senses are only emergency senses, to be used in the dark or where sight cannot be used.

For the last few years the author has conducted a series of tests in his classes in psychology in the Stevens Point State Normal School, for discovering the types of mind of the students in these

classes. There were three kinds of tests. All those tested were subjected to the first two sets of tests, and many received also the third set. The second and third sets of tests were planned to be confirmatory of the first set, and in a surprising number of cases proved to be so. These tests may be easily used by the reader to test himself or other adults, or any children under his charge.

The first test was a number of simple questions, which were answered in writing by each student and the answers handed in. The following are the directions, which the reader may try for himself:

First, hold the mouth open and try to image the words "mother," "bottle," "trumpet." If you can image the words visually with no trouble and no tendency to close the mouth, you are of the visual type. If you can image the words auditorially you are probably ear minded. If there is a strong tendency to close the mouth, and impossibility of imaging the sight or sound of the words clearly, you are of the motor type.

Second, picture any absent room. Can you see it all at once clearly? If so, you are of the visual type. If you must move your eyes slightly, even if closed, and construct the image piece by piece, you are at least partly motor.

Third, do you recognize friends directly by the sound of the voice, or when you hear the voice do you first picture the friend to yourself visually? If the first case is true you are of the auditory type, if the second, you are of the visual type.

Fourth, how do you recall musical notes?

(1) If you hear them in your head and are able to image a note higher than you can sing, hum, or whistle, you are of the auditory type.

(2) If you feel them in your throat or mouth and cannot image higher than you can sing, hum, or whistle, you are of the motor type.

(3) If you recall in terms of a visual musical scale you are of the visual type.

Fifth, how do you commit to memory? If by simply looking at words and remembering and recalling them as written or printed, you are of the visual type. If you learn more readily by hearing the words you are of the auditory type. If you remember and recall better by pronouncing the words aloud or by writing them out when you are learning them, you are of the motor type.

Sixth, how do you dream? In pictures, in sounds, or in movements and touches? If mostly in visual pictures you are of the visual type.

Seventh, how do you read to yourself? If by

simple inspection through the eye, you are visual. If by translating the seen word into mental sounds you are auditory. If by slight articulatory movements of the throat, tongue, or lips, you are motor.

Eighth, can you do mirror writing easily and quickly, that is, write from right to left, in a reverse order from the usual way? For a strong visualizer this involves a confusing mental reversal in visual terms, and is very difficult, while for the motor person it involves only symmetrical muscular feelings and is easy. Very few people will be of the same type by each test, but we classify any one by the majority of the results.

The second test given by the author to his students was to ask them to write a short description of a country walk, without telling for what purpose. These stories were brought to class and each student was asked to count the number of visual, auditory, and motor or tactile images indicated by the words of the description. The majority of cases showed a close agreement between the type of predominant images in the description and the results in tests under number one. In order to give the reader an idea of what these stories were like in the case of a pronounced visualizer, we will give here the description written by

a young lady of seventeen years of age, who was reared in the country and was found by all the tests to be mostly visual in her mental imagery:

A Country Walk

"The walk which I shall describe was taken in the early fall. The leaves of the trees and bushes were beginning to change from green to brown, yellow, or red, and the woods looked very beautiful. As I walked down the road I saw cattle and horses in the fields, and a large flock of sheep in one particular field. The grain was all cut and threshed, and about the barns of the farms were the straw stacks. The corn was cut and standing in shocks in the fields.

"About the farm houses and barns that I passed I saw the chickens being fed by the small children, who took great delight in watching the chickens scramble for the food. Farther down the road, and in the woods on one side, was a brook, which wound around among the trees and finally came out to the meadow. I followed this brook to the meadow and saw many things. Every little while a partridge would fly up and away from almost under my feet, or a rabbit would hop away into the bushes and tall, mottled grass. At one place along the brook it was necessary to cross on a

fallen tree. I was not sure of my foothold as I crossed, for although the stream was narrow at this point, the water was unusually deep and swift, and I did not relish the thought of a ducking. I landed safely on the other side, however, and continued my progress down the stream. Once in a while I would see trout dart out from the shadows of the banks and move swiftly away from my sight. I would hear a splash and a frog had taken alarm at my approach.

"So I wended my way down the stream, and came out on the meadow, beyond which was a long stretch of woods. I followed the stream to the bridge, which I crossed, and followed the lane to the road again."

It will be readily seen that this is a typical visualizer's description. There is one auditory image and a few motor images, but the greater number of images indicated are of things seen.

The third test for type was a simple indirect test as suggested by Binet. This test is especially applicable for young children, who are not old enough to do the introspection demanded in test number one, or to write a description as in test number two. The test is as follows:

Display or uncover a list of ten written words of one syllable, one every two seconds, and have

the class write the words remembered at the end of the exercises. Pronounce ten other simple words at intervals of two seconds and have the children write the words remembered at the end of the exercise. Give another list, pronouncing the words as above and then have the students write and pronounce aloud each word as they write, and then rewrite at the end of the exercise the words remembered. The first lot is to test visualizers, the second, audiles, the third motiles, or else the mixed type. Whichever list a child recalls the most words of determines his type. In a few days test your conclusions by seeing which list is best remembered by the different pupils. The results obtained by the author from Normal School students with this test were to a marked degree in accordance with the results of the other two tests mentioned above.

The results of the three tests given by the author to students in the Normal department of the Stevens Point Normal School during the last three years are as follows:

Type	*Number*	*Per Cent. of Whole*
Visual	263	57.7
Auditory	18	4.
Motor	62	13.6

Type	*Number*	*Per Cent. of Whole*
Visual and Motor [1]	26	5.7
Visual and Auditory [1]	35	7.7
Motor and Auditory [1]	5	1.
Visual, Auditory and Motor [1]	47	10.3
Total number of students tested	456	100.0

It is often claimed that women and girls are 95 per cent. of the visual type. The experience of the author does not make the percentage so large, but as the following table will show the visual type did predominate in the majority of cases among the Normal School young women tested:

Type	*No. of Women*	*Per Cent.*
Visual	241	59.1
Auditory	16	3.9
Motor	50	12.3
Visual and Motor [2]	25	6.1
Visual and Auditory [2]	32	7.9
Motor and Auditory [2]	3	.7
Visual, Auditory and Motor [2]	41	10.
Total number of women tested	408	100.

[1] These were cases where two or more types of images were found equally in one person.

[2] Equally mixed.

The next table shows that the visual type was found to be predominant also among the young men, but only in a plurality of the cases:

Type	*No. of Men*	*Per Cent.*
Visual	22	45.8
Auditory	2	4.2
Motor	12	25.
Visual and Motor [1]	1	2.
Visual and Auditory [1]	3	6.3
Motor and Auditory [1]	2	4.2
Visual, Auditory and Motor [1]	6	12.5
Total number of men tested	48	100.0

The above tables certainly indicate the predominance of visualization as the favorite imagery of the 456 students who were tested, and they may be taken as fairly typical of average intelligent young people.

There are a great many advantages in being of the visual type. Learning to read or to spell is easier for those of this type. Words and their correct spelling forms are constantly being impressed upon their memories in their favorite imagery as they read. Those of auditory type must hear the words pronounced and spelled aloud

[1] Equally mixed.

in order to get them in their favorite imagery. The motor type must write out the words or pronounce and spell them aloud to get them into their favorite imagery. The quickest students to commit things to memory are visualizers. They need only look at the page carefully and it photographs itself on their memories. When they wish to repeat the words they need only to reproduce them as printed on the page. One reason why girls learn by rote more readily is because they are more likely to be visualizers than boys.

In mediæval times when the possessors of a classic or old manuscript could make a living by reading a little every day to a class for substantial fees, those of the auditory type of mind had the advantage, for they could remember better what they heard, as it was in their favorite form. The Nominalists of the later Mediæval and the early Renaissance periods were evidently audiles because they pronounced the common noun a mere "vocis flatus," i.e., "sound of the voice," while the Realists were evidently visualizers because they thought the common noun stood for some ideal something which they claimed could be seen under proper conditions. So one of the great historic disputes, which split the world into two hostile camps from 1100–1500 A. D., was prob-

ably more or less due to differences among thinkers as to types of mental imagery.

Modern civilization, with its multiplicity of books, newspapers, magazines, movies, typewriters, sight-seeing trips, pictures, etc., more and more tends to develop the vision and to make more and more common the visual type of mind. No more does the family gather around the fireplace and talk or listen to one of the group read from some precious book. Every one in the family has his book, magazine, or paper, and reads for himself. The art of conversation, which cultivates the auditory and motor sides of the mind, is more and more falling into disuse. We cannot converse, we cannot write the charming letters as in old times. We can only read and see. Vision is indeed becoming the "Queen" of the senses, and visual images are becoming the predominating imagery of the memory and the imagination.

Even in mental arithmetic the visualizer has a great advantage, if he will use it. A good visualizer can take, for instance, 497, and multiply it by 565 by ordinary long method multiplication, setting down the results in his mind and adding them up as if he were working with pencil and paper. Such a problem is an absolute impossibility to a motor or auditory mind.

But it may be said that this excessive visualization is not an unmixed blessing. It is so easy for the visual minded person to learn the mere printed words and to repeat them from the memory pictures, without thought or understanding. This is not real expression or development of mental power. To see, remember, and recall a mere panorama of words and objects, to read and read and never talk it over or write about it, or work out anything from it with the hands, is to make the mind a mere passive visualizing machine, just a living camera plate.

It is difficult for the pure visualizer to think in abstract terms. Very few noted scientists or scholars are visual in type. The artist, architect, or designer is likely to be. There are some peculiarities about the way visualizers represent abstractions, such as numbers, for instance. These peculiarities in number representation of visualizers were first suggested to the writer by Angell in his psychology. Several classes of Normal School students were tested by the writer in this regard. They were asked to diagram how they saw the numbers from one to one hundred. The auditory and motor types could not diagram, for they do not see figures. They hear the names or feel the incipient articulatory efforts in the throat,

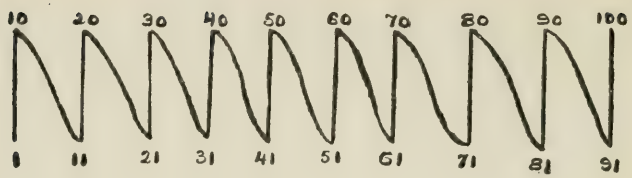


FIGURE 21

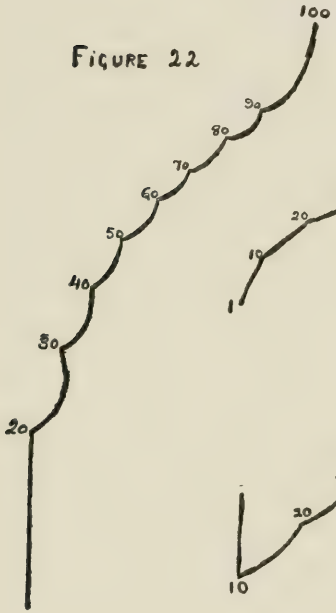


FIGURE 22

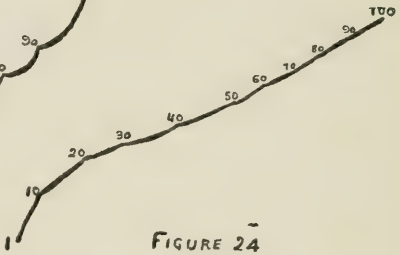


FIGURE 24

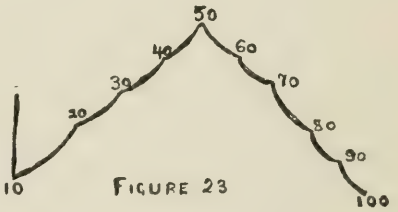


FIGURE 23

but from visualizers some surprising results were obtained. A few of the diagrams are reproduced here. (See Figures 21, 22, 23, 24, 25.)

Since the visualizer learns so readily he must be induced to vocal and motor expression to really develop in mental power and become truly edu-

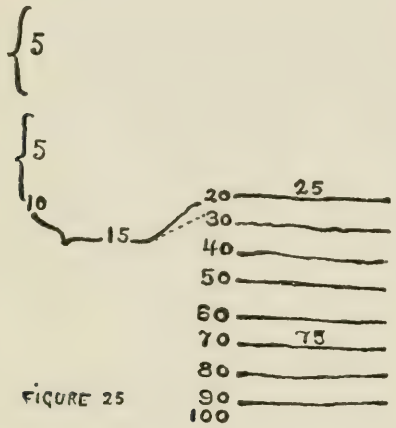


FIGURE 25

cated. Hence the prime necessity of manual training, dramatization, elocution, composition writing, gymnasium work, drawing, music, cookery, and sewing, for the modern child.

The best type of mind to cultivate is the mixed type, where the visual, auditory, and motor images are equally used and recalled. As Comenius and Pestalozzi, Froebel and Montessori all in-

sist, the eyes, the ears, and the hands must all be trained so as to work together in harmony, and although vision may predominate the other senses should each have their share in learning and remembering.

CHAPTER VIII

VISION AND EMOTION

Our treatment, so far, of vision has been almost entirely on its intellectual or knowledge giving side, but it seems hardly fair to ignore the close and vital relation existing between vision and the emotional and æsthetic sides of our natures, for in the last analysis pleasure and pain, joy and sorrow, love and hate, beauty and ugliness, are the real underlying forces and values in our lives.

Feelings and emotions are, however, much more indefinite and personal than images and thoughts which represent objects common to all who sense them, and hence the relation of vision to emotion is harder to make clear and definite, as these relations differ so in different individuals and different races. What " looks good " to one person may be very disagreeable to another. We can express our thoughts and our ideas of things more easily than we can express our feelings, our emotions, or our æsthetic appreciations.

The senses of smell, taste, and touch are pri-

marily protective senses, biologically necessary for our existence, and with them are connected most of our direct physical pleasures and pains, pleasure indicating beneficial stimulations and pain indicating detrimental stimulations. We generally find pleasure agreeable and pain disagreeable. Pleasure is always accompanied by expansion and movement toward the beneficial stimulation, while pain is accompanied by contraction and movement away from the detrimental stimulation. Pleasure then, may be called nature's approving signal, and pain nature's warning signal, and each is closely connected with our biological welfare and development, both as individuals and as a race.

Physical pleasures and pains are, however, simple states compared with the more complicated agreeable or disagreeable states we call emotion. Pleasures and pains do not necessarily need any intellectual apprehension for their occurrence. The microscopic amoeba in the drop of water evidently experiences pleasure and pain, judging from its expansion under beneficial stimulation and its contraction and withdrawal under detrimental stimulation, but we cannot attribute to the amoeba any emotion or æsthetic appreciation. The earthworm undoubtedly can feel pain and pleasure, but who would attribute to it love or

hate, joy or sorrow, or appreciation of the beautiful?

In exceptional cases like that of Helen Keller, the three biological senses may by training and education be able to give ideas and knowledge, which, affecting a nervous system inherited from a long line of seeing and hearing ancestors, may be able to produce higher emotions and æsthetic appreciation, but for seeing and hearing people these two far reaching and knowledge giving senses give us most of our stimulations, in association with the biological senses, for the æsthetic as well as the more violent emotions.

Vision is, as has been said, by far the most far reaching and knowledge giving sense, and for its interpretation and use requires intelligence and an appreciation of the remote, which cannot affect us by immediate pleasure or pain. The agreeable or disagreeable feelings we get through vision are not through immediate pleasures or pains. It is doubtful if a thing can be so ugly or so horrible that the mere sight of it can give a feeling of actual pain, or so beautiful as to give an actual sensuous pleasure by the mere sight of it, without other sensory associations. Ugly things do not actually hurt the eyes, neither do beautiful things actually benefit the eyes. The disagreeableness or agree-

ableness are parts of very complicated mental states requiring ideas and imagination, and are the result not only of bodily reactions, but require experience and associations. A cut, a burn, a broken limb, any results of a biologically injurious stimulation is painful to any living creature, but the sight of a wound or injury in another may or may not excite horror or pity in the observer. It depends on the temperament, experience and training of the observer. If a child who had never seen a lion should see one approaching he might laugh with glee, but if the lion caught him and bit and clawed him he would feel pain just as an adult would. An adult, however, who knew what a lion was, and the danger, would be filled with a terrible emotion of horror if he saw one approaching him. He would, however, feel no actual pain until the lion caught him. It can readily be seen then, that some perceptions and experiences and associations, coupled with widespread and instinctive bodily reactions, are necessary to cause visual impressions to bring about emotion, either violent or æsthetic.

Vision, then, causes in us emotions that are the result of our racial and personal adaptation to environment. We perceive the outer world through vision and the perceptions cause in us

varying emotions depending upon our bodily reactions to this or that object. Things are not made to be attractive or beautiful or disagreeable or ugly to us, but we have become adapted to the world as it is. Hence those objects in which we see health and benefit arouse in us emotions that are agreeable, such as love and joy, admiration and hope, while objects in which we see danger and harm arouse in us disagreeable emotions such as fear and grief, hatred and anger. The perception of the beneficial object causes increased heartbeat, quickened respiration and circulation, enlivening extensor movements, and such bodily reactions coalesce with the perception or memory or imagination, and on account of their association with pleasure, give us a pleasant or agreeable emotional state, while the perception of the harmful object causes contraction of muscle, a drawing away, lowered or irregular heartbeat, decreased circulation, trembling and coldness of the limbs, and on account of their association with pain, cause us to feel a disagreeable emotion.

The body is constantly reacting to our visual impressions. In many cases the thing seen is so commonplace and we are so used to it that it causes little or no bodily reaction and hence no perceptible emotion. But strange objects, or important

objects, harmful or good for us, or objects that possess attributes we call beautiful or ugly excite in us more bodily reactions toward or away from them, and give us stronger emotional excitement. One may pass a thousand people and experience slight emotion, but if one suddenly and unexpectedly sees a dearly beloved person, the heart beats faster, the face flushes, the respiration quickens, the lips smile and strong joy and love are felt. The sight of a person who has injured one causes just the opposite reactions and emotions of hate and anger.

So our visual images are constantly playing upon our nervous systems and exciting in us various emotions, some violent, and some placid æsthetic emotions, and no two people are excited exactly alike by the same objects, although, unless there are some personal associations that enter in, all objects that are biologically helpful excite pleasurable emotions and vice versa. Those peculiar individuals who find objects and actions disagreeable and ugly that most others find agreeable and beautiful, and things agreeable and beautiful which others find distasteful and horrible are likely to be eliminated in the struggle for existence.

The blue of the sky, the green of the grass

and leaves in the spring, the sparkling of the sun on the water, the ripening peaches, the golden grain, the shapes of animals, the lines and proportions of the human form,— all these objects and colors connected with our welfare and happiness, by inheritance and association excite in us pleasurable emotions. It is probably doubtful if we can say that one color is more pleasant in the abstract and in itself more beautiful than another, although it is probable that a scarlet sun and sky would be disagreeable to us because our eyes are better adapted to a blue sky and might be more easily fatigued by a red or scarlet sky than by the more delicate blue. Yellow is a heavier and more destructive color to the retina than blue or green, and should theoretically be less agreeable or beautiful to us, but some people prefer yellow to blue, green, or violet. Most people, however, prefer the three latter colors. But if a person had been bitten by a green snake, or had been mired in a green swamp, or had lost a friend in the blue sea, those colors naturally beautiful to many might seem ugly and horrible to such a person.

We have mentioned how, when colors are together, there are certain harmonies between them that are pleasant, e.g., between red and green, and yellow and blue, but that some people prefer the

more exciting results given from discordant colors together, such as red and yellow, or red and purple but most cultured and civilized people would consider such color taste to be uncultured and unæsthetic. We might perhaps conclude, then, that the human eye has become adapted by a long evolution to find certain colors naturally more agreeable and æsthetic than others, and certain color relations more harmonious, but we must admit many exceptions and contradictions to the common æsthetic values of colors, due to personal associations and experiences with different colors in objects. Red may be thought a beautiful color, but it may become horrible to a person who had seen his house burn or the red blood of a friend flowing from a terrible wound.

In regard to the beauty of form and outline of objects it is also hard to say that this or that curve or line or proportion is in the abstract and by itself naturally more beautiful, we will say, because more easily taken in by the eye. Rounded and curved and proportionate lines were formerly supposed to appear more beautiful to man because our eyes moved more easily over such lines, but the fact is that the eye moves in a jerky way from point to point; it does not follow a flowing curve any easier than a jagged and angular line. It

would seem, then, that if rounded forms and flowing curves and symmetrical proportions are more pleasant to us than angular forms and unsymmetrical proportions it is because of associations of an agreeable sort, which we have with the rounded, the curved, and the symmetrical. We not only get visual and muscular sensations from the eyes, but we also have suggested by the visual impressions associated agreeable and disagreeable sensations and perceptions which have been gained in the past. For example, the sight of a piece of silk or velvet may seem beautiful to us because of the associated smoothness and delicacy which such objects have when touched, whereas a rough, harsh object looks ugly to us and seems disagreeable because the touch of it is disagreeable. The ripe peach looks beautiful to us because it suggests an agreeable taste and touch sensation. A skeleton looks ugly and horrible to us, not because it is harder or more disagreeable for the eye to run it over than over a living form, but because it means death and decay. The rounded and curved human form looks to us, of all objects, the most beautiful, not because it is easier for the eye to take in than the skeleton, but because the curves and fullness mean health and life. We see beauty, then, in those objects that mean health,

life, joy and happiness. We project our agreeable emotions caused by such objects into the objects and think of them as being beautiful.

The seeing of beauty depends somewhat on inheritance, somewhat on associations gained by contact with environment, and by training and education, as do also all of our more biological and exciting emotions. The eye does not consume or destroy anything by looking at it. One may look at the ripe peach again and again and not destroy it. If one eats it, of course, it is destroyed. Through vision one gets the beauty of the peach, through the taste only sensuous pleasure. Things may be merely sensuously agreeable or disagreeable through taste, smell or touch. Through the eye they are beautiful or ugly. Since the vision can be excited without destruction of the object, the agreeableness of seen objects seems to be, as Marshall claims, a sort of an objectified pleasure with a permanent possibility of revival. The pleasure can be felt by any one who has eyes to see and a mind to experience, such pleasures, as we have said, being due to many inherited reactions, and to many acquired associations, and are not direct sensuous pleasures, as in the cases of the three biological and immediately protective senses.

CHAPTER IX

THE DEVELOPMENT AND TRAINING OF VISION IN THE CHILD

It would seem fitting to devote one chapter to the subject of the growth and development and training of the power of vision in the child, since the highest usefulness of such a grand sense as vision certainly should be developed in every individual.

Our education has neglected any special sensory training seemingly on the theory that we have only to take the individual when he is old enough to have his higher intellect trained and trust that the senses and sense material have correctly developed themselves. This attitude probably was due to the influence of Plato and to the excessively ascetic ideas of the Middle Ages when the senses were despised and contemned, and thought to be of the earth earthy. The soul was supposed to be capable of soaring to realms above the senses and without their aid. Indeed the old idea of the best and ideal character was that of a saint with his senses undeveloped or atrophied, dwelling

in pure realms of ecstatic heavenly bliss, far above any actual relation to the material world or to any information gained through the senses. This view could be held only where the soul was regarded as an ideal being entirely above and beyond the senses, and only waiting to cast off the clog that they put upon it. We are all familiar with hymns that voice the idea of the drag that the base senses are to the aspiring soul. Such a view was really inconsistent, and a libel on the Creator, and on the wonders of our bodies and of the world. Again, our greatest poets, as Shakespeare, Browning, Goethe, our greatest painters and sculptors, our greatest musicians, have been almost universally, men of superb sense endowment and development. The men, indeed, who have really left the richest and most enduring and helpful legacies to the world have been men in whom every avenue of sense perception was open for the world to speak through. The idea that to be deaf, blind, and senseless to the world is to be more spiritual can only be held in an extremely misanthropic, diseased, and abnormal age. The greatest character of all times, Christ Himself, was evidently the farthest possibly removed from any asceticism. He was a Man of supreme sensory endowments and training. A carpenter, a

lover of nature, an observer of all sense objects. This is witnessed by His life, His works, His parables. If ever a being was close to nature He was, and to be close to nature, and to be useful, helpful, progressive and happy, good sensory endowment and all around sensory training is necessary. We may wrap ourselves in a Stoic cloak and retire into our poor cell of subjective personal life, draw our soul into this shell like a hermit crab, refuse to see nature and to love it and adjust ourselves to it, but the result will be as poor a soul development as the hermit crab is a physical development. We are in a world of objects, a rich, constantly changing world. For the adapting of ourselves to the world we have sense organs, and without these organs and without using and developing them, are destined to be total blanks.

The intellect is directly developed from sense material. We have already discussed this in the chapter on visual perception. The intellect is not a mere empty receptacle to be filled with undiscriminated sensory material either. It is an activity by means of which sense impressions are transformed into these new products which we call cognitions or ideas. You can no more have a mind without sensations than you can weave a

rich tapestry without many colored threads. The more varied in color the threads the richer the tapestry, the wider, more accurate, and the more manifold the sensations, the broader and richer the mind resulting.

The Mediæval and the Renaissance education of the child, indeed all education before Pestalozzi and Froebel, totally disregarded sensory training. The kindergarten ideas, object lessons, drawing, clay modeling, nature study, the Montessori materials and exercises are all of comparatively recent development in the education of children, and are yet only partially in vogue. The queer idea still prevails that the senses do not need any care. That it is unimportant whether the sense organs are physically developed or whether the powers of seeing, etc., are properly trained or not — that by some hocus-pocus, the mind can develop and build up with imperfect and untrained sense organs and senses.

More even than in the past, the senses must be deliberately trained, especially in the crowded city where the rich sensory material and appeal of nature that country life affords, is lacking.

In the first place, we must be sure that each child's sense organs are healthy and normal and work perfectly as physical organs. How many

children are counted dull and stupid by parent and teacher because, for example, they have some serious eye defect. Of course not only must there be good eyes, but also a sound and healthy brain, for it is in the visual centers of the brain that vision takes place. An idiot may have as good eyes as a normal child, but due to his defective brain he cannot interpret the visual material that comes to his brain through the eyes.

There are these admitted natural differences of sense capacity due to differences in the mechanical perfection of the sense organs or to the congenital brain cell endowment, but even these can be largely overcome by care and training unless there is an actual complete loss and lack of the sense organ. There is no child, who has eyes, who is so dull as not to see something, and who cannot be interested and led to see and discriminate more. Until the mind is aroused to activity through sense experience and sense preception all the mental processes are slow and inefficient.

How fallacious and barbarous the old idea of deductive bookish education! To put a child to book and rote learning at five or six, before he had had any apperceptive background to understand words and books, was to cripple him mentally for life and to make him a living phono-

graph or camera, a mere passive recorder of non-understood words. The child, if anything, is sensory. The world of objects and movements appeals to him. He spontaneously delights in seeing, handling and doing. A new object, a new color, a new sound, is a delight to him. How foolish then, to take him from objects, from play, from seeing, from the free activity of his senses, and at a tender age to put him to learning rules, abstractions, and general ideas, meaningless facts from books, printed symbols of a world he does not yet know — dim shadow for beautiful reality! We are slowly coming to see that he must grow and be educated according to his nature; at first in contact with the concrete, and then slowly by induction and by progressive personal experience to the abstract and the general; from sensations to thought, from objects to ideas, from the natural to the ideal world; always by observation and induction, not by rote or rule learning.

In our discussion in the chapter on space perception, we saw that the world is at first to us a chaos with no meaning, no form, no solidity, no distance, no size, no objects. We are much less developed at birth in our sensory power than are animals. In a day or so after being hatched, young chickens will follow moving objects, and

pick up clover seed, estimating distances with great accuracy. All animals seem to exhibit a much higher degree of relative sensory ability at birth than does the human being, but this very fixity and maturity of sensory power at birth renders farther and greater development along these lines impossible for the animal. The human being, however, having possible such a complicated and intricate sensory and associative mechanism, cannot develop before birth but must have long years of sense experience before this mechanism is perfected; hence the necessity of much sense material and training being furnished.

In the actual development of the senses we know that sight and touch do not develop separately but are developed together. Yet they can be developed separately, since the blind child can construct a space world by touch alone, though a limited one, while we must doubt if sight ever could be developed so as to give correct ideas of the size, distance, and solidity of objects without the coördinate development of touch and sight. But here we will speak of the sight alone.

At the age of three or four years the child often astonishes us by his precision of sight and by his quickness and sureness in seeing many things. Indeed, he often sees more than we suspect or

want him to see. He is interested in almost all objects indiscriminately, but especially in brightly colored objects, in moving objects, in animals of all kinds, in other children and people. He has few special interests formed as yet, and hence he sees almost everything with equal curiosity. By this omnivorous curiosity he learns to know many things and lays up a background of apperceptive material for the future knowledge of the outside world. In adult life we are often preoccupied with inner thoughts, wrapped up in this or that intellectual problem, and hence we may look upon outer objects and actually not apperceive them at all, although they may cast images on the retinas and cause sense impressions in our minds. The child, however, free from all engrossing thought, and with the representative or inner functioning of the mind as yet relatively small as compared to the merely presentative, finds everything fresh and interesting, and is eager and anxious to see; his whole soul, so to speak, is in his eyes.

The young child of the age above mentioned is, however, very often confused, inaccurate and chaotic in his seeing. He is a victim of his surroundings, a follower of the nearest and latest impression. Years of training and experience are necessary for reliable, connected, and intelli-

gent seeing. And yet we can all remember the interest, the freshness, and the curiosity of youth, and how marvelous things seemed. We were not yet abstracted nor fixed in lines of interest, hence we looked at everything. We can feel, to an extent, the return of our childish freshness and joy of vision, an unreserved giving up to the delights of mere seeing, when we go to a new city or country, but even then, we do not have the naïve vision of the child. We see according to our training and experience. How important, then, that the training of our vision should be of the helpful and varied sort.

The sense of sight, like all the other senses, is governed by a natural and a progressive development. The eye learns to see, just as the tongue learns to speak and the legs to walk by slow stages and progressive practice and experience. Or, to put it differently, the eye, at first, must be trained as a mechanical apparatus and certain physiological adjustments must be made, but after that there must be the more important development of the inner interpreting discriminating power, the formation of the apperceptive masses of visual ideas, as the Herbartians call it, the reaction of the inner self activity, the growth in the number of visual ideas or memories, and then intimate

and useful connections, so as to form a stock of visual images by which to interpret, perceive, and know objects. The dog, the idiot, the savage, the bright child, the scientist, all may have equally good eyes as far as the mechanical visual apparatus is concerned, but they do not perceive the same, even though the same visual images fall upon the retinas of each. The inner representative interpreting power of the mind must be added to a well developed and perfectly adjusted visual apparatus, if sight be both keen and discriminating. Lack of mental background and training is even more fatal to seeing than actual dullness of eyes.

The young child is lacking both in actual physiological adjustment of his visual apparatus, as well as in perceptive interpreting power. Now to perceive, you will remember, he must first get a stock of sensory images. Perception is a sensation plus a reproduced sensation. First then, for visual perception there must be a well adjusted mechanical apparatus of sight, so as to give clear sensory impressions, for only thus can future sensations of sight be interpreted correctly. Perception then, or seeing as we experience it in adult life, is not possible from the first day of life, since the eyes and eye movements are not adjusted or

coördinated, and again because there is no inner interpretative or mental material for reaction yet present, no stock of sensory images yet attained. During the first three months, even, the child's visual apparatus is not adjusted. He receives sensations of light from the start, but can by no means perceive objects for a long time. The child's eyes must go through a sort of evolution, analogous to that which the development of sight in animal life has gone through. At first a mere shrinking from light, a mere susceptibility analogous to the nerve spots of invertebrate, then a love of light, attraction toward bright objects, forming of habits of directing the eyes, forming of habits of fixation upon objects, power of recognizing objects, of discriminating color and form, and finally, of appreciating size and distance. All this is learned only slowly and by a constant progressive development from vague undiscriminated sensations of light to discrimination, analysis, synthesis, and perception of objects. The child must learn by exercise all that nature endows the lower animals with in the beginning, all that she suggests to them by blind and irresistible instincts. But here again, on account of the necessity of the child's learning to see, is the line of power and possibility of vision wonderfully extended, since

it is not forever set and limited by the iron laws of instinct.

All writers agree that the child is partially blind at birth. He sees enough, if normal, to distinguish light from darkness but not enough to distinguish objects, even if he knew enough to distinguish them. For the first two weeks of life most children manifest an aversion to light and close the eyes at once when exposed to it. After about fourteen days the eyes get accustomed to light and the child begins to manifest a real liking for light. Making a light will often quiet him. This vague pleasure in mere light is followed after a few weeks, by a staring at bright objects or light which happen to fall within the field of vision, and the first things the eyes begin to follow with evident pleasure are candles and lamps. If the candle at which a child is staring is moved out of the line of vision, the child's eyes will wander about aimlessly. It takes a long development before he is able under such circumstances to find the light again. His eye movements at first are unsymmetrical and uncoördinated, and the intentional use of the eye movement is learned very slowly by much experience. Out of many uncoordinated, useless, aimless movements grow coördinated, purposeful movements. Another

reason why he cannot follow a light moved away from his line of vision is because at first the retina is sensitive only at the very central point, and the outer zones of the retina grow slowly sensitive from the center outward. Retinal sensibility and coördinated eye movements develop slowly together.

The mechanism of accommodation also is untrained at first. All children are originally nearsighted. A lighted candle which will attract the attention of a young child, when close to him, is lost to his view if removed to a greater distance. The mechanism of accommodation must be developed by long experience and coördination with touch and the movements of the body, to have meaning. It is only slowly and by innumerable associations of looking at objects, and reaching, creeping, and walking to them that the accommodation and convergence strains from the eyes come to have definite meaning, and a child three or four years of age is very inaccurate as to the distance and size of objects. Not much before six years of age is a child's visual perception of size and distance to be trusted. This would lead us to infer that a child must have abundant outdoor exercise and movements, and as much as possible, actual relations to objects and the natural world.

Objects of all sizes must be offered to him for comparison and at different distances, and must not only be seen by him, but touched and walked to, so that both sizes and distances can be compared and learned.

It seems altogether likely that for some time, varying in different children, differences of color are not felt but only differences of brightness. The color sense and color discrimination, like all the other adjustments of the eyes, require time. The correct color discrimination, and especially correct recognition and naming of colors is an effort of which many adults even, are incapable. Although a certain small per cent. of adults are more or less color blind, it seems certain that the perfectly normal child for some time after birth is color blind. The probability is that there is no accurate discrimination of colors felt by the child until he is three or four years old, and then the discrimination is exceedingly imperfect and proceeds very slowly, and requires much time and training.

The investigation of color discrimination in children is exceedingly difficult until they can talk, but even with children four to six years of age there is difficulty in getting them to name colors, even though they can match them and recognize

them. The child must not only learn to feel color differences, but also to intellectually perceive and recognize each color, and then learn the name and associate the color name with the color. This is all very difficult and requires much experience. The child, we have said, at first is merely susceptible to brightness, but very soon he gives evidence to being sensitive to color. Pink or red ribbons lighted by the sun, a gilded frame, a bouquet of flowers, all bright colors, soon come to please him. To state when he passes from mere sensations to light differences and begins to discriminate colors is impossible, for children differ exceedingly in this regard and hence the reports of every observer differ. The colors that seem to be first distinguished are red and yellow. The child's eyes seem to be impressed by the heavy and powerful ether waves of the red and yellow lights, while the faster and lighter green and blue waves are probably seen by him as gray. The child, like the savage, is first attracted by the bright colors and broad contrasts, and only slowly learns to distinguish the more delicate shades. The world to him, must be one grand mosaic of colors until he learns that these different masses of color are different objects at different points in space.

From the world of colors the child passes to

the discrimination of the world of form. He first must distinguish color then different areas of color or surfaces. After differences of the areas of surfaces are discriminated, he begins to perceive different objects. He begins to get knowledge of the outer world. He begins to see a world in space and gradually to learn the names of objects and take attitudes toward them.

It will be seen from our brief discussion of the development of sight, that it is a slow, progressive evolution in each person and hence implies a great deal of experience. Not only must the eyes and the nerves be developed and strengthened so as to enable one to see, but also attention, curiosity, sympathy, astonishment, intellectual and moral instincts must appear and grow if there is to be a real and true development of vision. The child at first sees merely automatically; he is a mass of passive visual sensations. Later he begins to see intelligently, to reach,— he looks. Only then does his glance become intelligent and his eyes show forth a personality.

The active seeing, the mental power to interpret, stimulation of attention, interest, and curiosity, all this can be aroused only by association with the wise and seeing parent or teacher. No child can see correctly. He needs help and direc-

tion, training and education given by some older person. Objects that train the vision are not lacking; everything appeals to the sight. Nature, in all her colors and variety, people, pictures, blocks, animals,— there is no lack of material. All these the child must be sympathetically guided to see and know.

The child should first be led to distinguish between different objects, forms and colors. Contrasts should be presented together, discrimination developed. Bright and striking color contrasts first, then fine shades. Widely different objects, then those more alike. Children have only vague ideas of form at first. From this vague, general apprehension of objects they must be led by slow degrees to clear percepts of objects in all their details. This requires active movements of the eyes and hands, close attention and learning of details and parts. Drawing, clay modeling, building with blocks, all these help in learning form, and always there should be close observation and contact with the varied and irregular forms of nature.

Before the child is introduced to books and book learning he should have a subprimary course to train his senses and develop his motor powers. The Kindergarten and the Montessori work

modified and combined by the skilful teacher is perhaps the best training that he can have at the present time. He must learn to see the world before he can imagine it from books. First the seen objects, then the imagined world.

CHAPTER X

THE HYGIENE OF THE EYE AND OF VISION

EVERY one who writes on the eye feels called upon to say something about the hygiene of this most valuable organ.

Happy is the person who never has his eyes forcing themselves upon his attention, but who sees always with ease and without conscious strain or feelings of irritation.

The eyes are naturally fitted for somewhat distant seeing. Our constant reading of books and doing of fine and detailed work from childhood, throws a great strain on the eyes and also, of course, brings to consciousness any defect in the structure and functioning of the eyes, which would be unnoticed in more primitive and outdoor life. There is no doubt but that the nervousness and dullness of many children are due to eye trouble unknown to the parent or teacher. Many children are so nearsighted that they cannot read the work the teacher puts upon the blackboard, or they have astigmatism and farsightedness, so that

all eye work on books or written matter is a terrible nervous strain. And yet we are so unobservant that such children may go on for years and their eye weakness be undetected. Every child in our schools should have his eyes tested at least once a year, and all cases of defective eyes should be recommended to a good oculist.

We are prone to abuse our eyes. We read facing the light, we read by poor or glaring light, we work on after we have feelings of strain and irritation, we do fine work that necessitates overstraining of the eyes. We neglect going to an oculist for fear we will have to wear glasses and mar our beauty. In many ways we abuse the most priceless of our sense organs and reap the punishment of impaired sight and headaches and excessive nervousness and irritability.

It would be good for sedentary and professional people to get away for awhile each year and never see a book or paper, or any near or fine work, but to roam the fields and gaze at the distant mountains or streams. Nothing rests the eyes like the relaxation that comes when looking far away. Even in the midst of our work we do well to stop every now and then and look off into the distance.

We wash every part of our bodies with unfail-

ing regularity but how many wash out their eyes daily? And yet an eye cup should be among the toilet accessories of every person and the eyes washed daily in a saturated solution of boric acid. There is no doubt that bathing the eyes in cold water every morning is stimulating and helpful, and in cases of irritation of the lids, bathing in hot water is beneficial, if one is careful not to expose himself to the cold air for an hour or so afterward. The author, however, has no intent to give a treatise on care of the eyes. The books on physiology and hygiene are full of this subject. He would, however, plead with the reader to prize his eyesight. He hopes that the story that has been told here of vision will lead to greater care and appreciation of the organs of vision. If any one's eyes are in the least defective or give the least trouble, the author's last word on the hygiene of the eyes is, see the best oculist *available at once.*

Besides the hygiene of the eyes themselves we may, from the psychological standpoint, speak of the hygiene of vision. The eyes may be all right, and yet due to a person's mental attitude and past experience and ways of seeing things, the mind may always take a diseased, morbid, unnatural, joyless view of the glorious and interesting world

of nature and of man. We have elaborated this in several places that we see what we see because of our mental make-up, and that with equally good eyes people will see things differently and with different degrees of clearness and completeness. It makes then a large difference what visual material comes into our minds. From early childhood images of all kinds are impressing themselves upon our consciousness. Our possibility of understanding and appreciating what we see to-morrow depends upon what presented itself to us to-day. Every sight modifies our power of seeing. If we constantly have the vicious, the lewd, the indecent, the horrible, forcing itself upon our visual sense, our minds cannot help but become of a like nature, and we will see everything in a tainted and perverted way. Some people flatter themselves that they can go slumming, that they can expose their eyes to immoral sights and not suffer, but no image ever impressed on the mind is lost. It becomes a part of that mind and, to a degree, affects its future vision.

There is, then, a mental hygiene. The mind grows pure and clean and healthy in its vision if the vision is exercised on the pure and clean and healthful. How important, then, to protect the child and young person from seeing the lewd, the

impure, the criminal, either in life or in pictures or movies, and on the other hand, to flood the minds of all with the bright, the pure, the natural, the beautiful, so as to build up in each the wonderful power of always seeing everywhere the good, the true, and the beautiful.

THE END

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